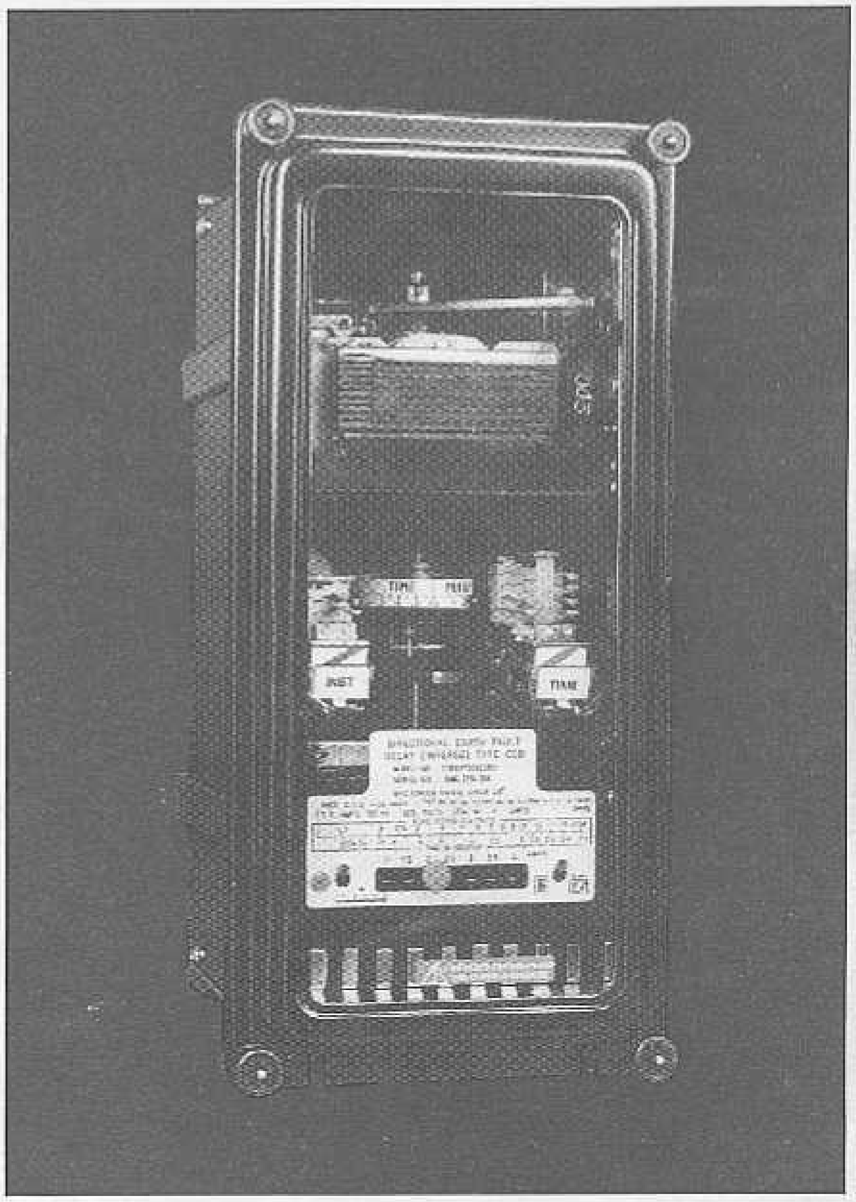
INVERSE TIME DIRECTIONAL NON DIRECTIONAL OVERCURRENT RELAYS TYPES CDG,CDD & CDG SERIES TRIP.



Commissioning Instructions

GEC ALSTHOM

INDIA

DIRECTIONAL & NON - DIRECTIONAL OVERCURRENT RELAYS

TYPES CDG 11 - 14 & 16, CDD 21, 23, 24, 26
CDG SERIES TRIP

INSTRUCTION & COMMISSIONING MANUAL

GEC ALSTHOM INDIA LIMITED
MADRAS - 600043

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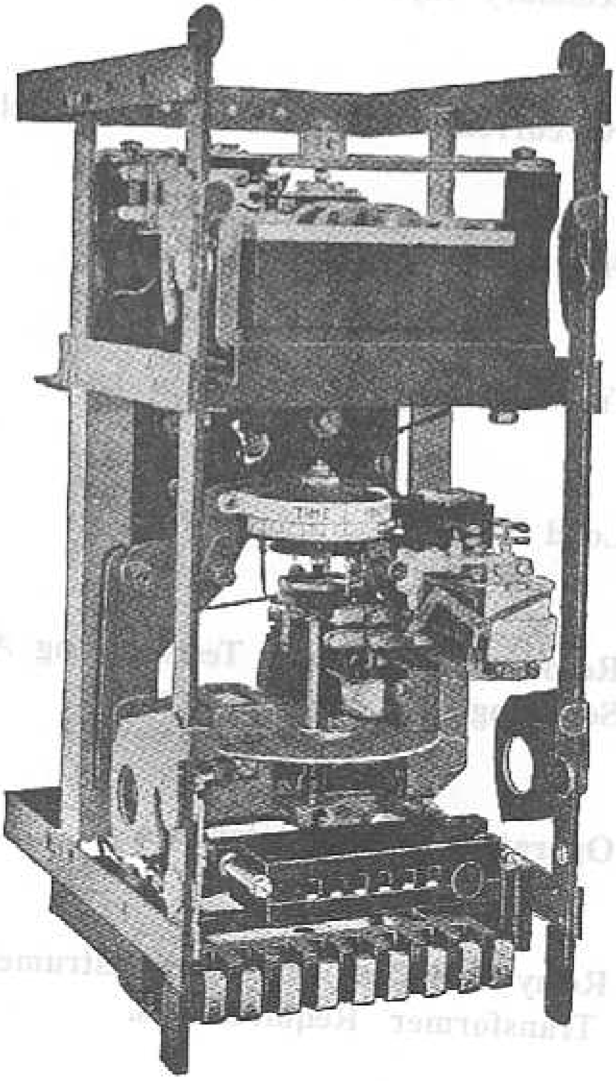


Fig. 1. Type CDD 21 relay in drawout chassis

1. INTRODUCTION

This manual covers the commissioning and maintenance instructions for various types of non-directional and directional inverse time overcurrent relays belonging to the CDG and CDD family. Each inverse time relay has a different time-current characteristic but all the relays have the same basic construction and vary only in minor details. For the sake of convenience, all non-directional relays are referred to as single-pole relays, i.e. CDG11, CDG12, CDG13, CDG14, and CDG16. However, all the information given in the manual applies to the double-pole and triple-pole versions also which are designated CDG21 and CDG31 etc. Directional relays are supplied in single pole versions only, i.e. CDD21, 23, 24 and 26.

Type CDG11 is an inverse time overcurrent relay with a definite minimum time. Type CDG12 is a long time delay relay. Types CDG13 and CDG14 are very inverse time and extremely inverse time overcurrent relays respectively.

Type CDG11 relay is used for protection against phase and earthfaults. The 50 Hz version has a time - current characteristic which conforms to I.S. 3231 (1965). Type CDG12 relay is used for stand - by earthfault protection of neutral earthing resistors and for other applications where long time delay is required (30 seconds at 5 times tap value). Type CDG13 is recommended where greater time selectivity than the CDG11 is required and the fault current at any point does not vary too widely with system conditions. Type CDG14 relay has an even steeper time - current characteristic than CDG13, permitting a graded setting in conjunction with fuses. With this characteristic it can also guard against overloading of machines and transformers by more closely matching the heating characteristics of protected apparatus than is obtained with the other relay characteristics. The time - current characteristic of the relays are shown in Figs. 27 to 31.

The CDG series trip relay has the same characteristics as type CDG11 or CDG14 relay, but is used where a separate tripping supply is not available. It is a modified version of the type CDG11 or CDG14 relay and trips the circuit breaker directly using current from the current transformer.

Type CDG16 relay is similar to CDG11 relay. In type CDG11 relay, contacts and operation indicators are provided on an auxiliary attracted armature unit of either series seal-in (current operated) or shunt reinforcing (voltage operated) type. In type CDG16 relay two pairs of electrically separate contacts and a mechanical operation indicator are provided on the induction disc element itself thus eliminating the auxiliary attracted armature unit.

In the later models of CDG11 / 31, the relay has been made self - powered. Thus there is no necessity for any separate auxiliary DC or AC supply for the relays. These relays are available in the standard current setting ranges of 50 - 200%, 20 - 80% and 10 - 40% of 1A or 5A.

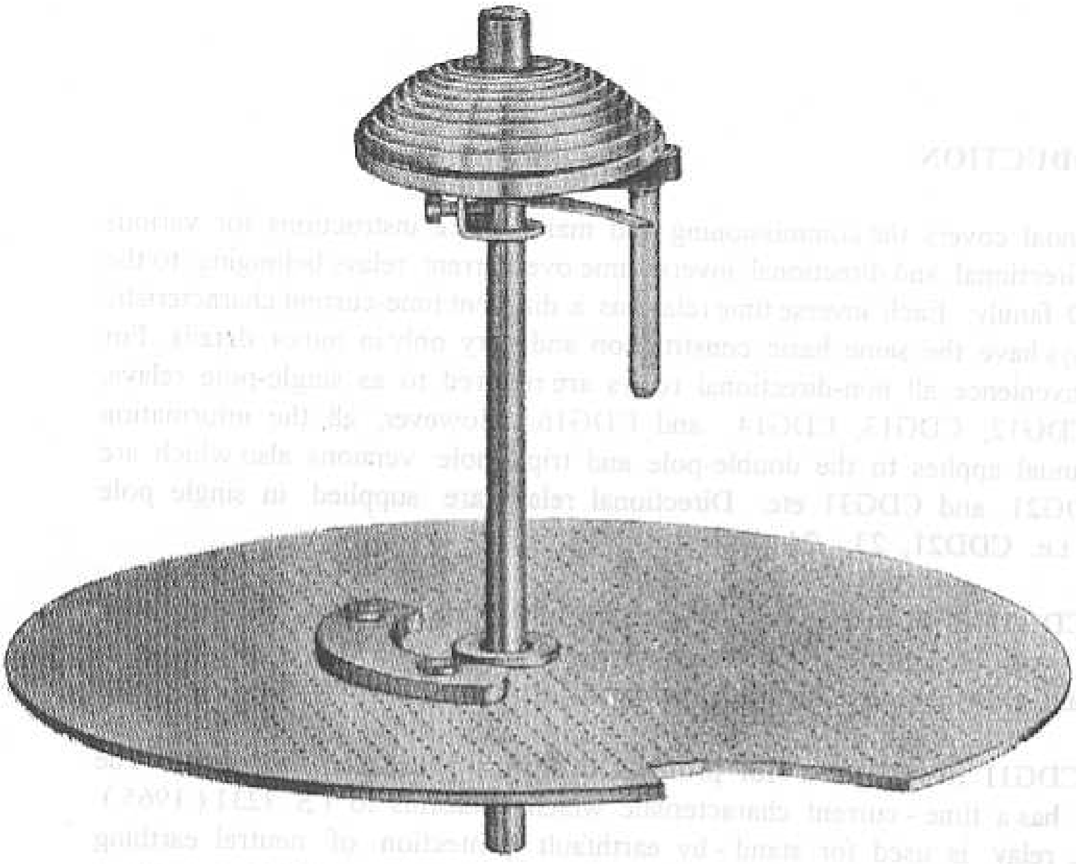


Fig. 2 Induction disc assembly

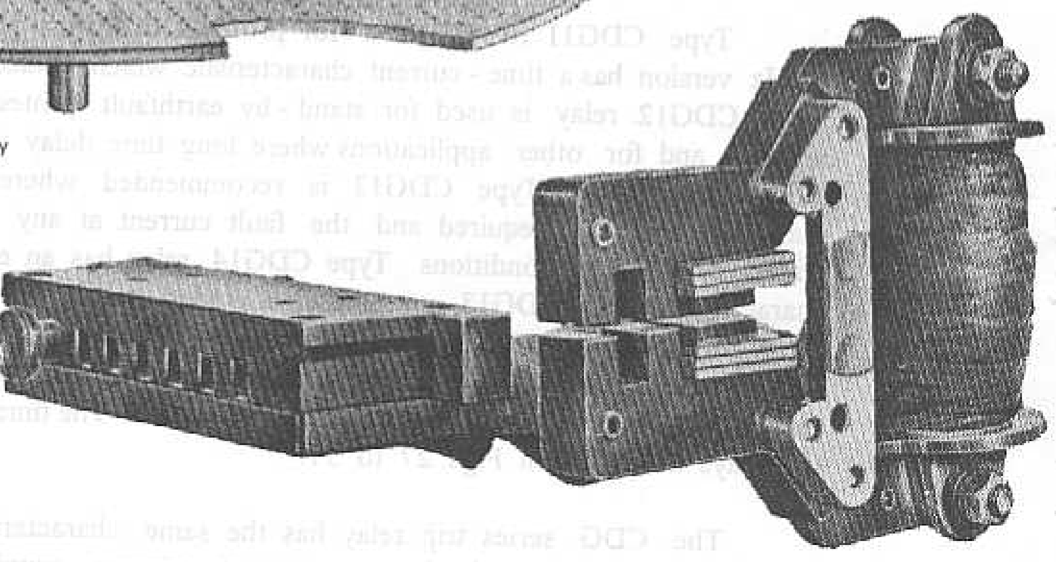


Fig. 3. Electromagnet assembly

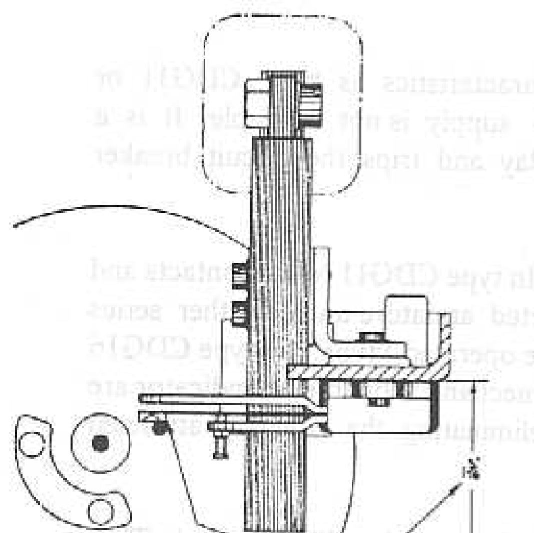


Fig. 4. Position of moving contact relative to disc shape

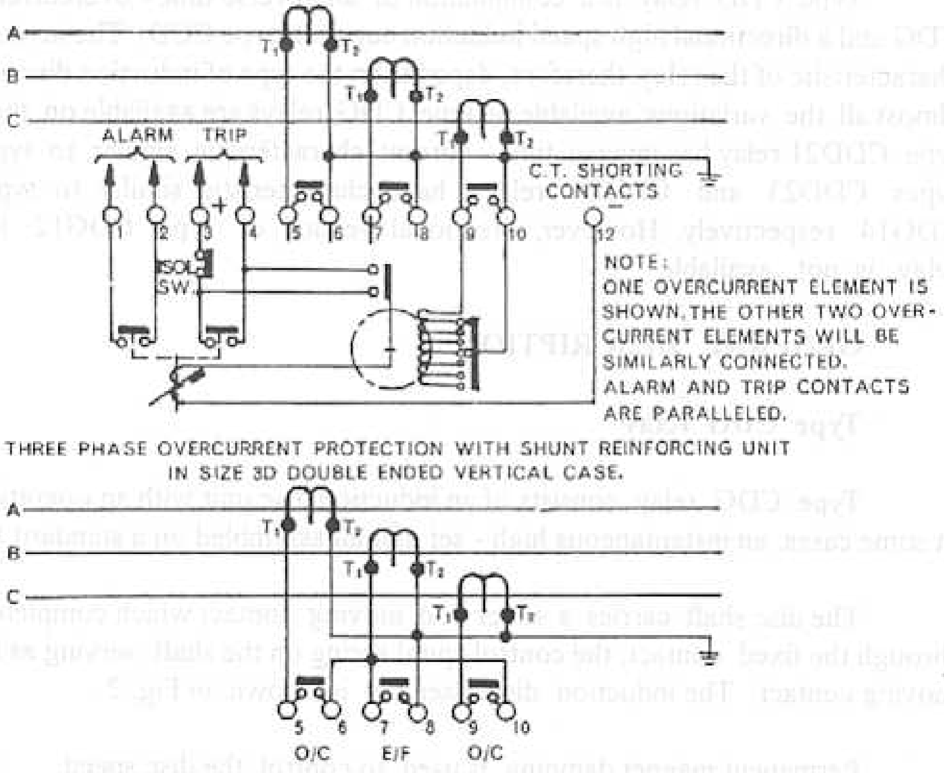


Fig. 5. C.T. Connections for three-phase overcurrent and earth fault protection in size 3D double-ended vertical case

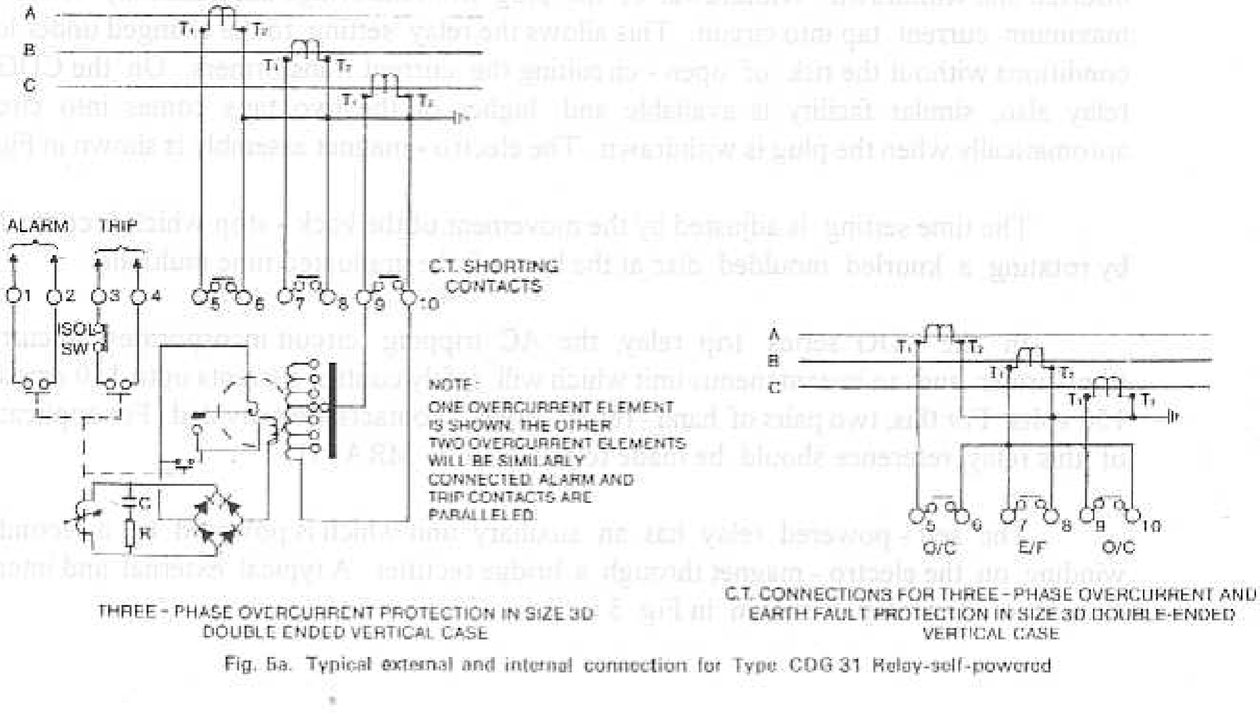


Fig. 5a. Typical external and internal connection for Type CDG 31 Relay-self-powered

Type CDD relay is a combination of an inverse time - overcurrent disc unit, type CDG and a directional high speed induction cup unit, type CCD. The inverse time - current characteristic of the relay, therefore, depends on the type of induction disc element used and almost all the variations available on type CDG relays are available on this relay also. e.g. type CDD21 relay has inverse time - current characteristic similar to type CDG11 while types CDD23 and CDD24 relays have characteristic similar to type CDG13 and CDG14 respectively. However, directional version of type CDG12, long time delay relay, is not available.

2. GENERAL DESCRIPTION

2.1 Type CDG relay

Type CDG relay consists of an induction disc unit with an operation indicator and in some cases, an instantaneous high - set unit all assembled on a standard frame.

The disc shaft carries a silver rod moving contact which completes the trip circuit through the fixed contact, the control spiral spring on the shaft serving as lead - in for the moving contact. The induction disc assembly is shown in Fig. 2.

Permanent magnet damping is used to control the disc speed.

Except on type CDG12 relay which has two current tappings only, the operating coil on the electro - magnet has seven taps, each of which is brought out to a socket on the plug setting bridge. The required tap is selected by means of a plug which can easily be inserted and withdrawn. Withdrawal of the plug from the bridge automatically brings the maximum current tap into circuit. This allows the relay setting to be changed under load conditions without the risk of open - circuiting the current transformers. On the CDG12 relay also, similar facility is available and higher of the two taps comes into circuit automatically when the plug is withdrawn. The electro - magnet assembly is shown in Fig.3.

The time setting is adjusted by the movement of the back - stop which is controlled by rotating a knurled moulded disc at the base of the graduated time multiplier.

In the CDG series trip relay, the AC tripping circuit incorporates a current transformer and an instantaneous unit which will safely control currents upto 150 amps. at 150 volts. For this, two pairs of hand - reset " break " contacts are provided. For application of this relay, reference should be made to publication MRA351.

The self - powered relay has an auxiliary unit which is powered by a secondary winding on the electro - magnet through a bridge rectifier. A typical external and internal connection for relay is shown in Fig. 5 (a).

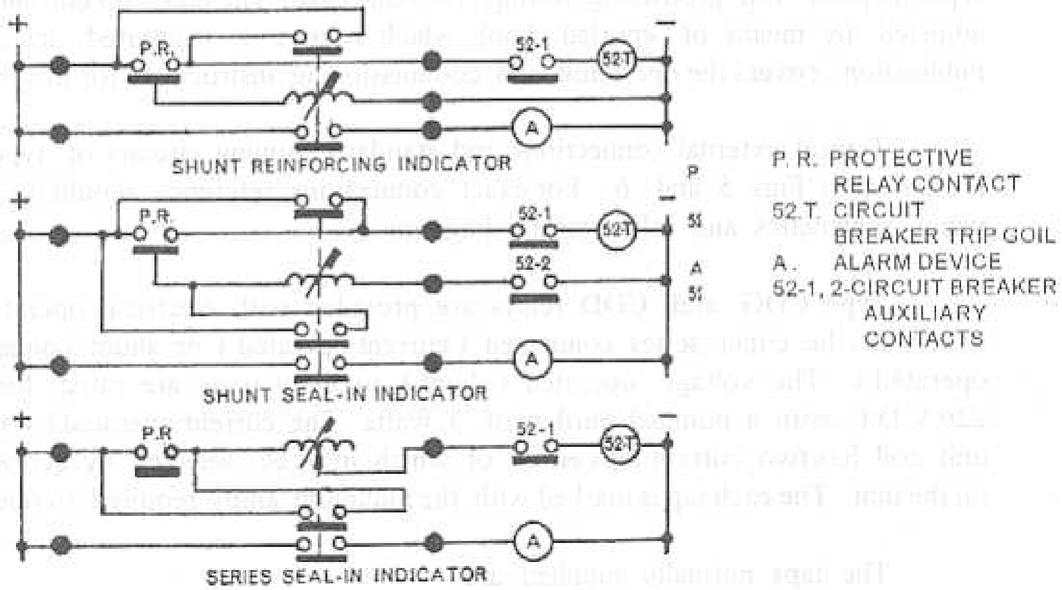


Fig. 6. Standard tripping circuits

When the current through the relay exceeds its setting, the disc unit operates and closes its contacts to complete the path for secondary winding. The auxiliary unit connected across the rectifier now picks up and one of its own N/o contacts reinforces the disc contact. The other contacts of this auxiliary unit are available for tripping and alarm purposes.

Relay models fitted with instantaneous element and directional unit are also available.

The instantaneous high - set unit, type CAG13 attracted armature relay, if provided, is fitted at the top left hand corner of the relay, with an operation indicator reset by a separate push - rod protruding through the relay case. The pick - up current of this unit is adjusted by means of knurled knob which rotates a calibrated scale. A separate publication covers the operation and commissioning instructions for this relay.

Typical external connections and standard tripping circuits of type CDG relays areshown in Figs. 5 and 6. For exact connections, reference should be made to the panel, schematics and relay wiring diagrams.

Type CDG and CDD relays are provided with electrical operation indicators which can be either series connected (current operated) or shunt connected (voltage operated). The voltage operated (shunt) auxiliary units are rated for 30, 110 or 220 V D.C. with a nominal burden of 3 watts. The current operated (series) auxiliary unit coil has two current taps either of which may be selected by screw connections on the unit. The each tap is marked with the minimum amps, required to operate the relay.

The taps normally supplied are :

Minimum operating current in amps. (two taps)	**0.5 second current rating in amps**	**Coil Resistance in ohms**
0.1 and 0.3	18 and 22	9.2 and 2.1
0.2 and 2.0	22 and 92	6.0 and 0.125
0.6 and 2.4	92 and 188	0.29 and 0.031

The single disc contact is rated to make and carry for 0.5 sec. 2500VA with maxima of 10 amps. and 660 volts AC or DC.

The two pairs of electrically separate, self or hand reset contacts provided in the auxiliary unit are rated to make and carry for 0.5 sec. 7500VA with maxima of 30 amps. and 660 volts AC or DC.

2.2 **Type CDD relay**

Type CDD relay consists of an induction disc type overcurrent unit and a high speed induction cup unit. The cup unit serves as a directional element and is mounted above the induction disc unit.

The induction disc overcurrent unit is similar to the standard type CDG relay described earlier, with the exception that the solid copper shading rings on the electro-magnet are replaced by wound shading coils. These coils are connected in series with the directional cup unit contacts. Therefore, operation of the directional unit short-circuits the shading coil of the disc unit and provides the flux displacement necessary for producing a torque on this unit. In this way, the operation of the overcurrent unit is controlled by the directional unit to obtain a directional characteristic for the relay.

Types CDD 21, CDD 23 and CDD 24 are directional versions of types CDG 11, CDG 13 and CDG 14 plain inverse, very inverse and extremely inverse time current relays respectively.

A highset instantaneous overcurrent unit, type CAG 17 can be fitted in the same case to provide instantaneous protection under maximum short circuit conditions and to improve discrimination on time graded protective systems. This highset unit can be directionalised if required. For full details of the highset unit refer to relevant publication.

Types CDD 21, 23 and 24 are single pole relays and are available in single pole version only. Types CDD 31, 33 and 34 are respectively types CDD 21, 23 and 24 relay with instantaneous units. Types CDD 41, 43 and 44 are respectively types CDD 21, 23 and 24 with directionalised instantaneous units.

Out of the above relays, CDD 21 and CDD 31 relays are self - powered and do not require any auxiliary supply. For typical External and Internal connection diagram refer Fig. 11A.

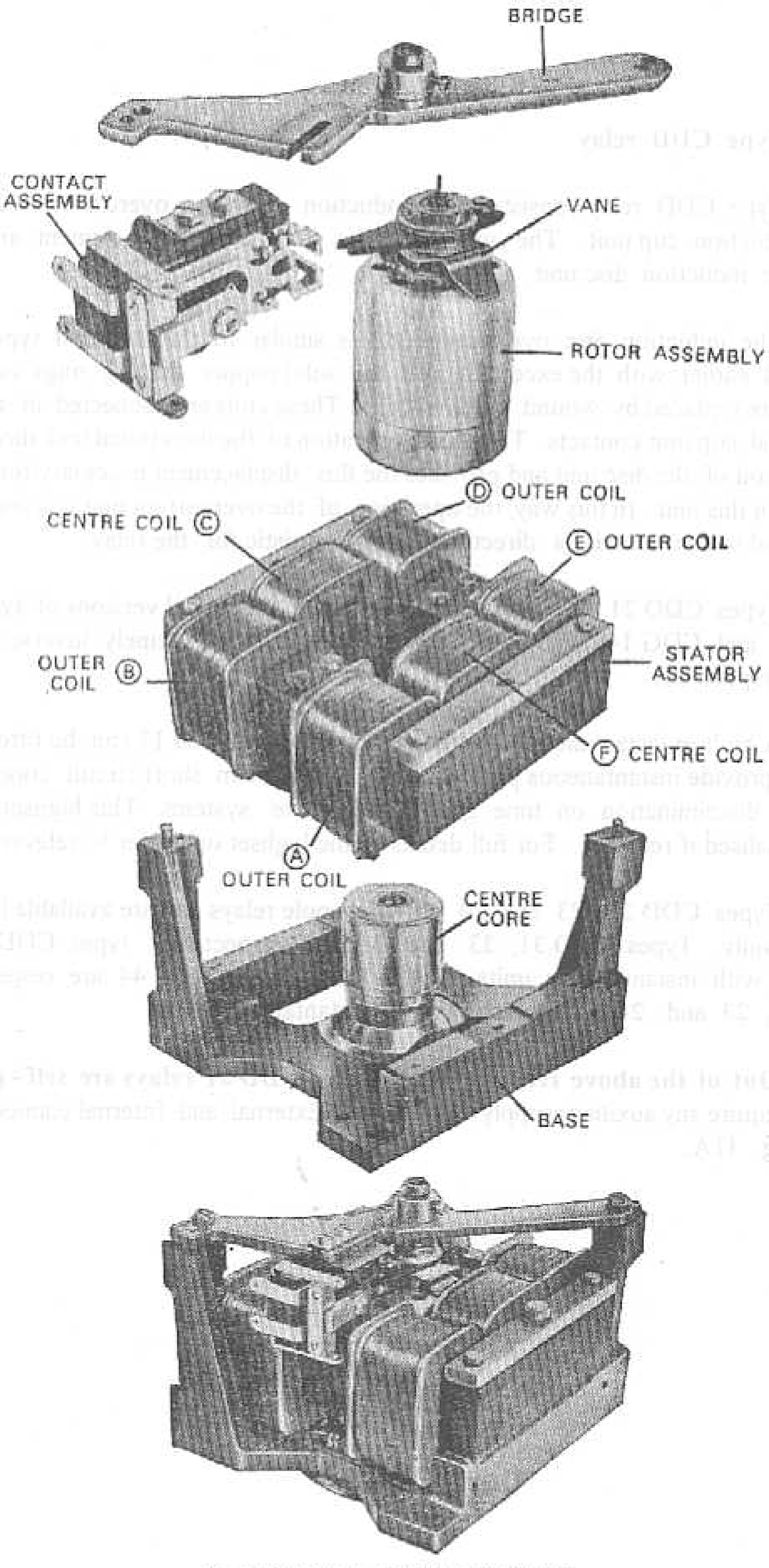


Fig. 7. Exploded view of Induction cup unit

2.3 INDUCTION CUP UNIT :

An exploded view of the high speed induction cup unit is shown in Fig. 7. The key to the component part is as follows :

2.3.1 The base :

The solid cast base supporting the core, the bridge and the lower jewel bearing of the induction cup, ensures rigidity of the unit and maintains accurate alignment of all parts.

2.3.2 The Cylindrical Core :

The laminated core concentrates the flux across the gap. It is provided with a flat so that rotation of the core will eliminate any I^2 torque. This adjustment is carried out inside the works and the core is locked securely in position. On no account should its setting be disturbed.

2.3.3 The Laminated Yoke :

The four pole laminated yoke carries the operating coil, the outer coils, A, B, D & E and the centre coils C and F. They are either current or voltage coils dependent upon the type of relay.

2.3.4 The Contact Assembly :

The contacts are silver cylinders mounted at right angles. The whole contact assembly can be easily withdrawn for maintenance and inspection.

2.3.5 The rotor :

The induction cup carrying the contact arm is of aluminium and provided with a thickened skirt eliminating up-thrust and minimising vibration. The adjuster vane provides adjustment for the elimination of V^2 torque. Its setting should not be disturbed.

2.3.6 The Bridge :

The bridge carries the top bearing and contact assembly dowels in the frame pillars ensure accurate alignment of the induction cup axis.

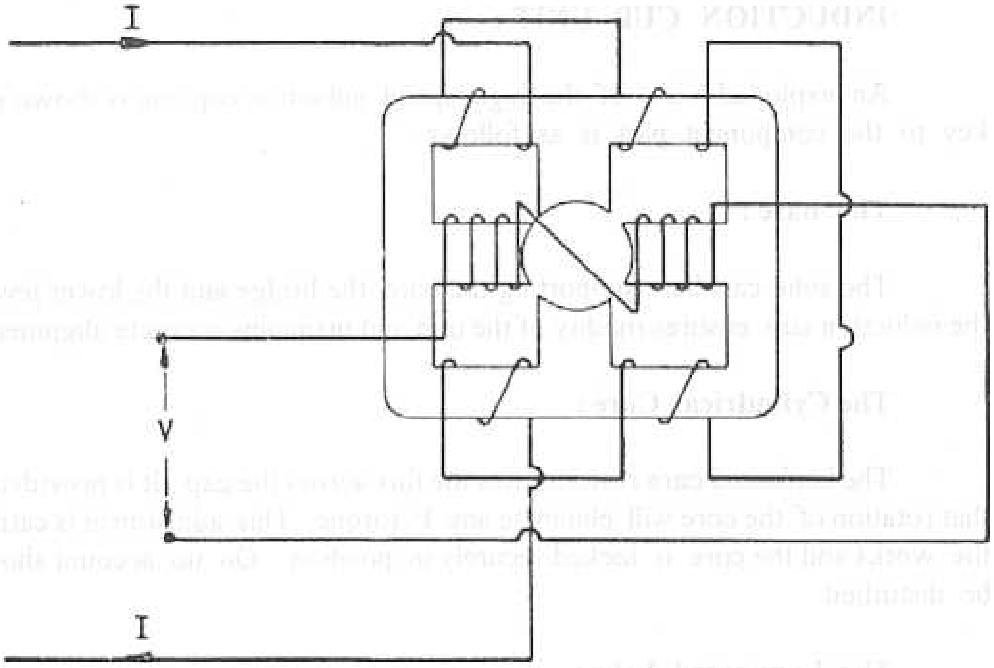


Fig. 8. Phase fault relay connections

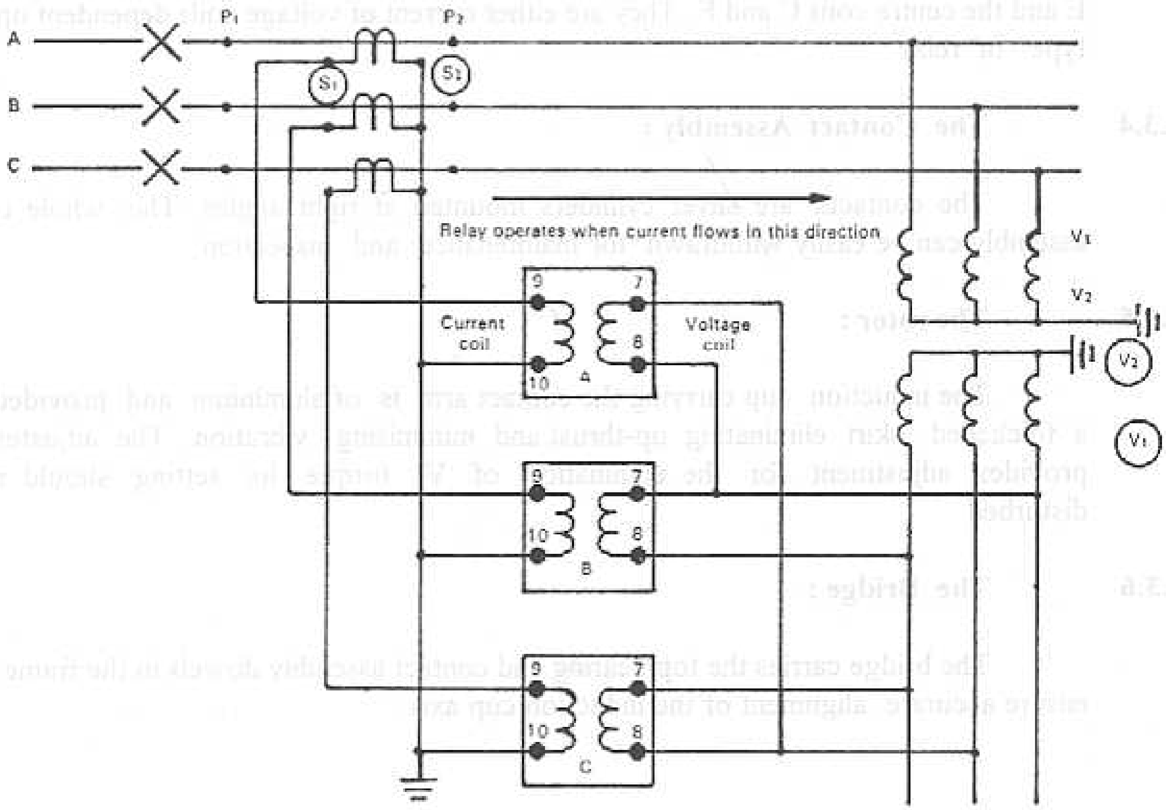


Fig. 9. Diagram of connections for type CDD relays (Phase fault relays—Quadrature connection)

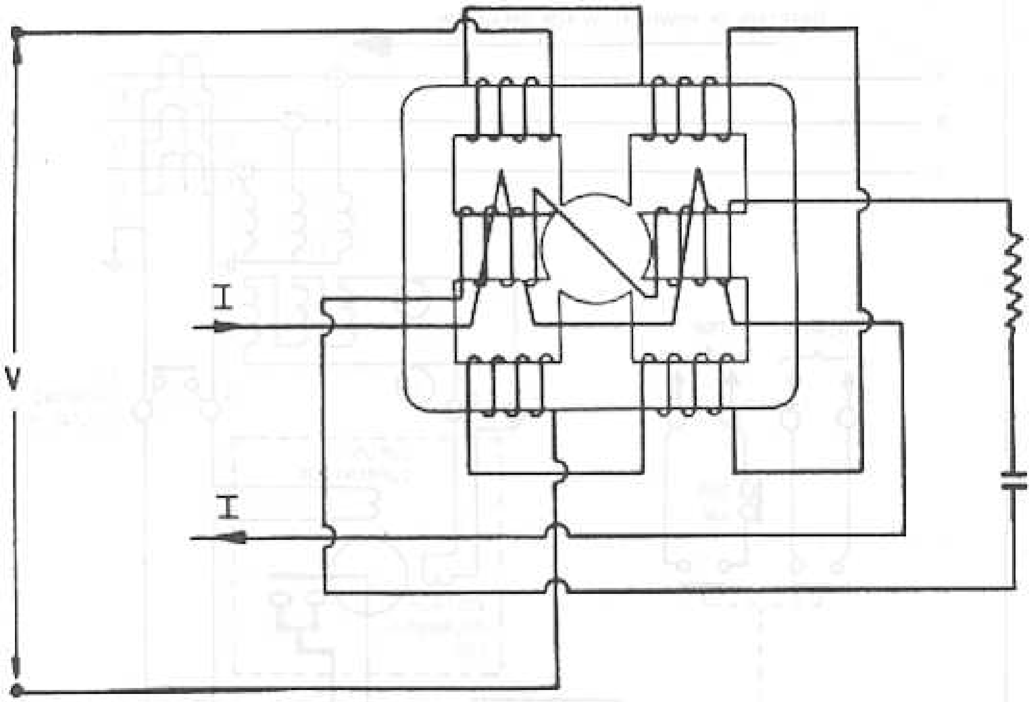


Fig. 10. Voltage polarised earthfault directional unit connections

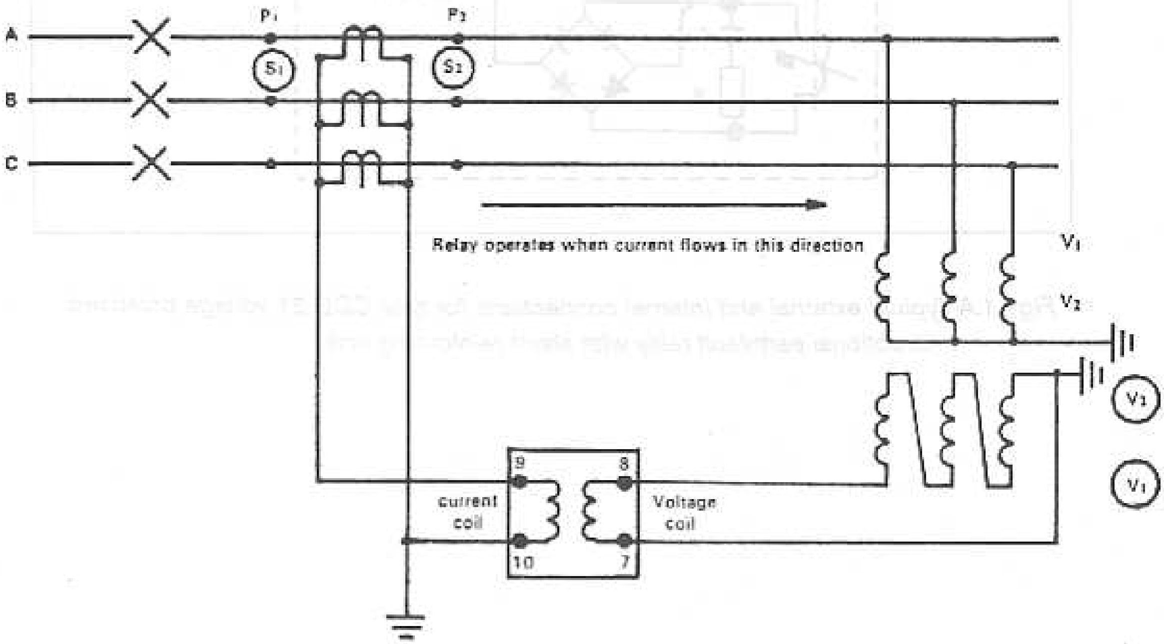


Fig. 11. Earthfault connections (Potential polarisation)

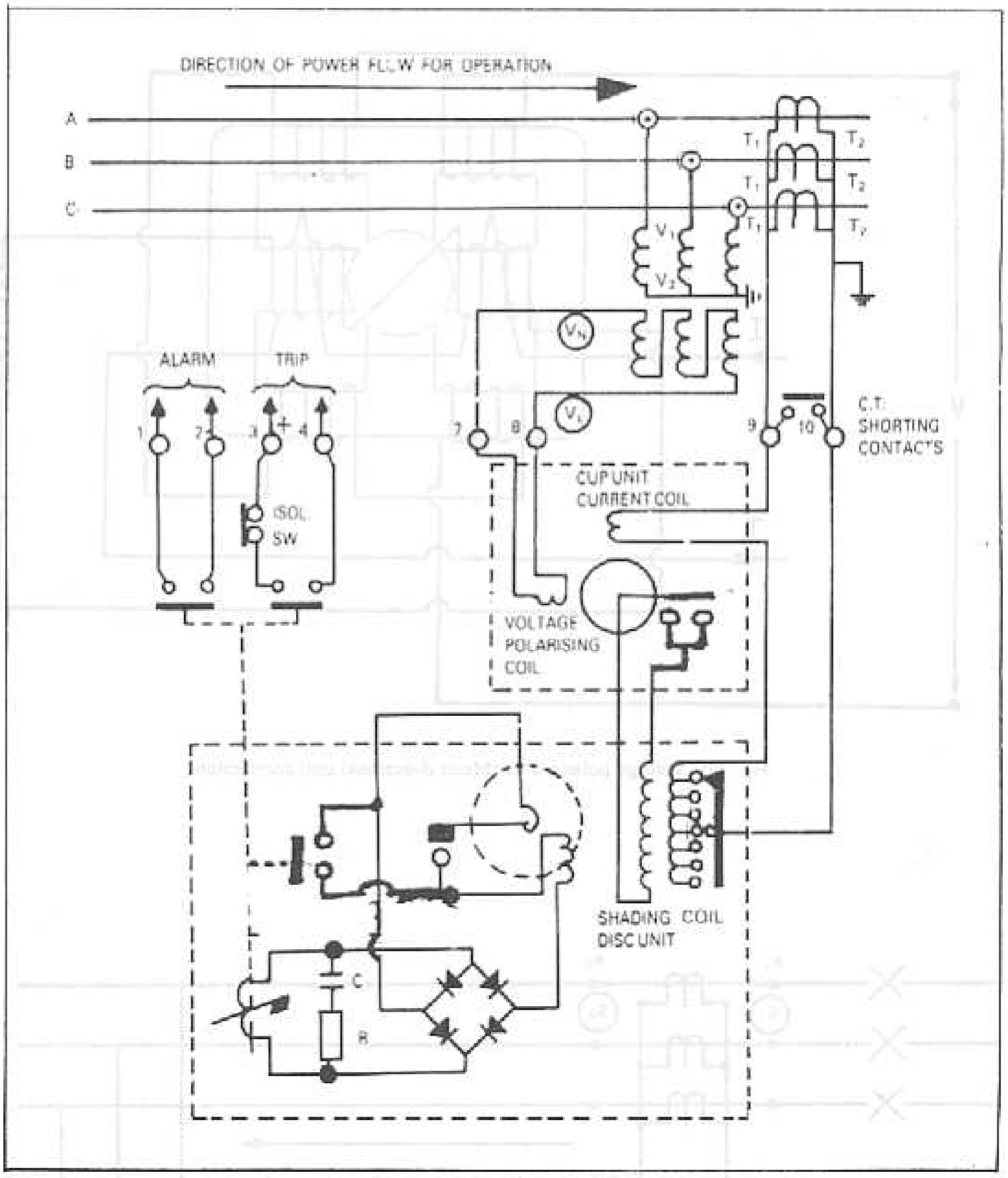


Fig 11.A Typical external and internal connections for type CDD 21 voltage polarised directional earthfault relay with shunt reinforcing unit.

The various types of directional unit for phase and earthfaults are as follows :

2.3.7 **Phasefault Relays :**

Type A - Maximum torque with the current leading the voltage by 30°

Type B - Maximum torque with the current leading the voltage by 45°

For both types, quadrature connection is used, i.e. current is supplied from one phase and voltage from the other two phases. Type B is similar to type A except that a resistance is connected in series with the voltage coil. The internal wiring of the directional unit is shown in Fig. 8 and the method of connecting these relays is shown in Fig. 9.

2.3.8 **Earthfault Relays :**

(Voltage Polarised)

Type A - Maximum torque with the current lagging the voltage by 60°

Type B - Maximum torque with the current lagging the voltage by 45°

These units differ from the phase fault units in that the position of voltage and current coils is interchanged and a phase shifting winding included on the centre limbs of the magnetic circuit is connected in series with a resistance and a condenser. Type B is similar to type A except that a resistance is used in series with the voltage coil. The internal wiring of the voltage polarised earthfault relays is shown in Fig. 10 and the method of connecting these relays is shown in Fig. 11.

2.3.9 **Earthfault Relays :**

(Current Polarised)

This unit is similar to the earthfault relay type A described above, but the voltage coils are replaced by a further set of current coils. The internal wiring of the unit is shown in Fig. 12. The relay has a maximum torque angle of 0°

It is important that for the correct reproduction of residual voltage across the broken delta winding of the voltage transformers, either three single - phase VTs or one three - phase five - limb VT should be used.

CDD relays are provided with electrical operation indicators and contacts for tripping and alarm as for the CDG relays.

The instantaneous unit type CAG17 can also be provided but this is not directionalised. Relays with special high-set unit which can be directionalised can be supplied on request.

3. INSTALLATION

LOCATION :

The location should be dry, clean, free from dust and excessive vibrations and reasonably well illuminated to facilitate inspections.

MOUNTING :

The relay case should be mounted on a vertical panel surface (within ± 5°) so that the disc of the induction unit is approximately horizontal.

DRAWOUT CASE :

The drawout cases are suitable for flush or projection mounting. For flush mounting screw clamps are provided on the side of the case. These clamps hold the flange on the front of the case firmly against the panel, and no drilling is required for fixing screws. For projection mounting two tapped bosses are provided on the back of the case for bolting to the panel.

4. COMMISSIONING :

The following tests are recommended for the initial commissioning of **CDG** and **CDD** relays :

(i) General inspection.
(ii) Wiring check.
(iii) Insulation tests.
(iv) Current / Voltage transformer checks.
(v) Operation indicator tests.
(vi) Secondary injection tests.
(vii) Trip and alarm circuits check.
(viii) Load tests.

A record of the commissioning test results should be compiled. By comparing the subsequent test results, the behaviour of the relays can be noted.

4.1 **General Inspection :**

Wipe away any dust that has collected on the outside of the relay before opening the cover. Make a general inspection of the relay to ensure that all moving parts are free to move and that there are no signs of damage anywhere. Check that there are no loose connections or terminals and that the equipment is clean and free from dust. General inspection is normally carried out after disconnecting the tripping supply.

4.2 **Wiring Check :**

Make a thorough check of the internal and external wiring of the relay. The internal wiring can be checked by reference to the relay wiring diagram which is supplied for each relay. The external wiring should be checked with the help of schematic diagrams (showing reference number of interconnecting wires, relay terminal nos., etc.) supplied by the relay panel manufacturers.

4.3 **Insulation Tests :**

Insulation resistance tests at 1000V DC are to be carried out on all AC and DC circuits to ensure that the wiring is in satisfactory condition. Tests should be carried out as follows :

For CDG and CDD Relays :

(i) Insulation resistance to earth of CT circuits.

(ii) Insulation resistance to earth of DC circuits.

(iii) Insulation resistance between DC and CT circuits.

(iv) Insulation resistance between DC circuits.

For CDD Relays only :

(i) Insulation resistance to earth of VT circuits.

(ii) Insulation resistance between CT and VT circuits.

(iii) Insulation resistance between DC and VT circuits.

When measuring the insulation resistance to earth of an individual circuit, all the other circuits should be normal, e.g. earth links closed and DC circuit normal. This will ensure that the insulation of this circuit is satisfactory, both to earth and to all other circuits.

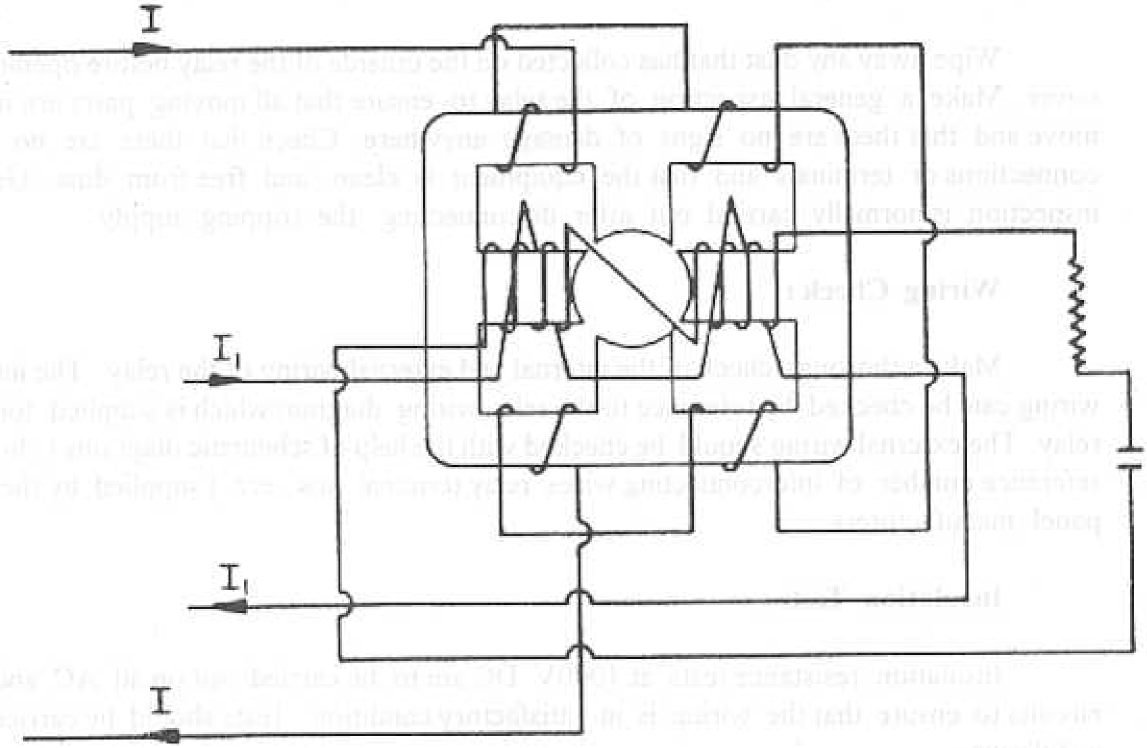


Fig. 12. Current polarised earthfault directional unit connections

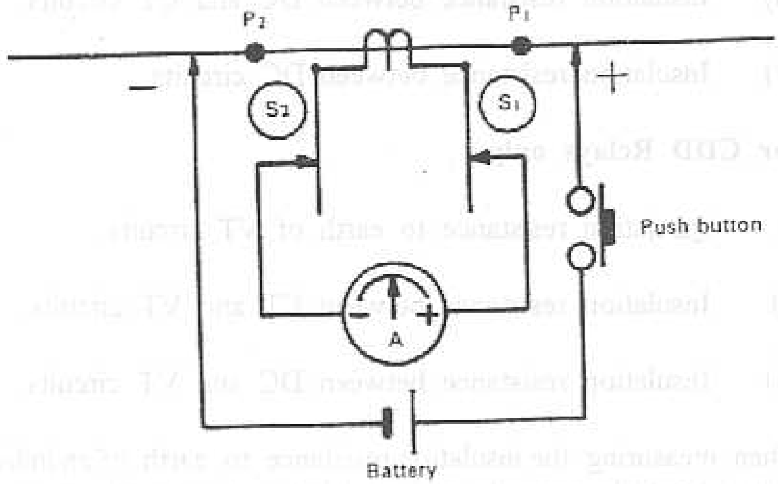


Fig. 13 Current transformer polarity check

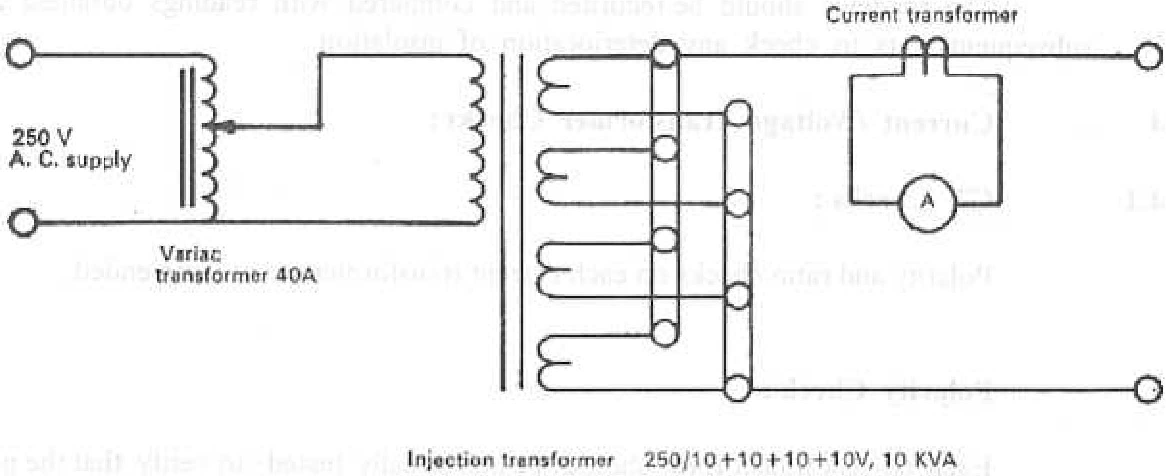
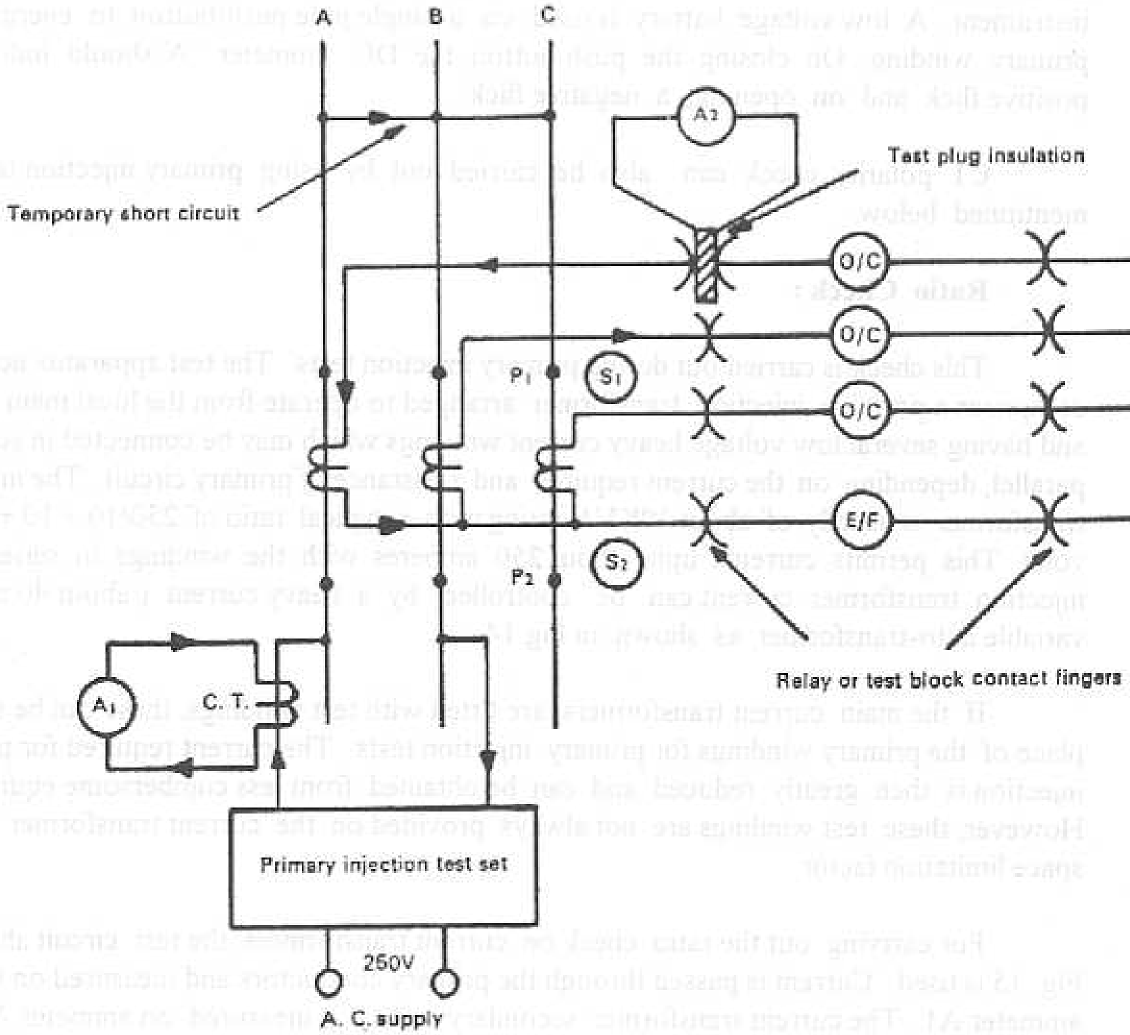


Fig. 14. Primary injection test set



The readings should be recorded and compared with readings obtained during subsequent tests to check any deterioration of insulation.

4.4 Current / Voltage Transformer Checks :

4.4.1 CT Checks :

Polarity and ratio checks on each current transformer are recommended.

Polarity Check :

Each current transformer should be individually tested to verify that the polarity markings on the primary and secondary windings are correct. Fig. 13 indicates the test circuit for this test. The ammeter 'A' is a robust, moving coil, permanent magnet, centre zero type instrument. A low voltage battery is used via a single pole push-button to energise the primary winding. On closing the push-button, the DC ammeter 'A' should indicate a positive flick and on opening, a negative flick.

CT polarity check can also be carried out by using primary injection test set mentioned below.

Ratio Check :

This check is carried out during primary injection tests. The test apparatus normally comprises a portable injection transformer arranged to operate from the local main supply and having several low voltage heavy current windings which may be connected in series or parallel, depending on the current required and resistance of primary circuit. The injection transformer is usually of about 10KVA rating with a typical ratio of 250/10 + 10 +10+10 volts. This permits currents upto about 250 amperes with the windings in series. The injection transformer current can be controlled by a heavy current (about 40 amps.) variable auto-transformer as shown in Fig.14.

If the main current transformers are fitted with test windings, these can be used in place of the primary windings for primary injection tests. The current required for primary injection is then greatly reduced and can be obtained from less cumbersome equipment. However, these test windings are not always provided on the current transformer due to space limitation factor.

For carrying out the ratio check on current transformers, the test circuit shown in Fig. 15 is used. Current is passed through the primary conductors and measured on the test ammeter A1. The current transformer secondary current is measured on ammeter A2, and the ratio A1 / A2 should be approximately equal to the ratio marked on the current transformer nameplate.

4.4.2 VT Checks (for CDD relays only)

Polarity, ratio and phasing checks on such voltage transformers are recommended.

Polarity Check :

The voltage transformer polarity can be checked with the test described for the current transformers by using a low voltage battery. Care must be taken to connect the battery supply to the primary winding, with the polarity ammeter connected to the secondary winding. If the voltage transformer is of the capacitor type, the polarity of the transformer at the bottom of the capacitor stack should be checked.

Ratio Check :

This check can be made when the main circuit is first made alive. The voltage transformer secondary voltage is compared with the secondary voltage of an existing voltage transformer connected to the same primary bars.

Phasing Check ;

The incoming secondary connections should be carefully checked for phasing. With the main circuit alive, the secondary voltage between phases and neutral should be measured and the phase rotation should then be checked with a phase sequence indicator. If a broken delta tertiary winding is involved, the voltage across the broken delta terminals should be measured with the rated three phase balanced voltage applied to the primary windings. The measured voltage should be less than 5 volts with rated burden connected.

4.5 Operation Indicator Test :

(a) If shunt connected operation indicators are used, their operation should be satisfactory at 75% rated DC voltage or 80% rated AC voltage. This can be checked as follows :

Insert a test - plug MPB into the relay, taking care to see that the CT secondary is shorted by means of a link on the plug.

Apply 75% rated voltage in the appropriate DC terminals of the relay. This can be done by using a suitable variable dropping resistor in series with the available DC supply. A voltmeter is required to indicate the magnitude of the applied voltage. In the case of AC auxiliary units, 80% rated AC voltage can be applied to the appropriate relay terminals by means of variac.

Close the disc unit contact by rotating the disc by hand and note that the auxiliary unit operates.

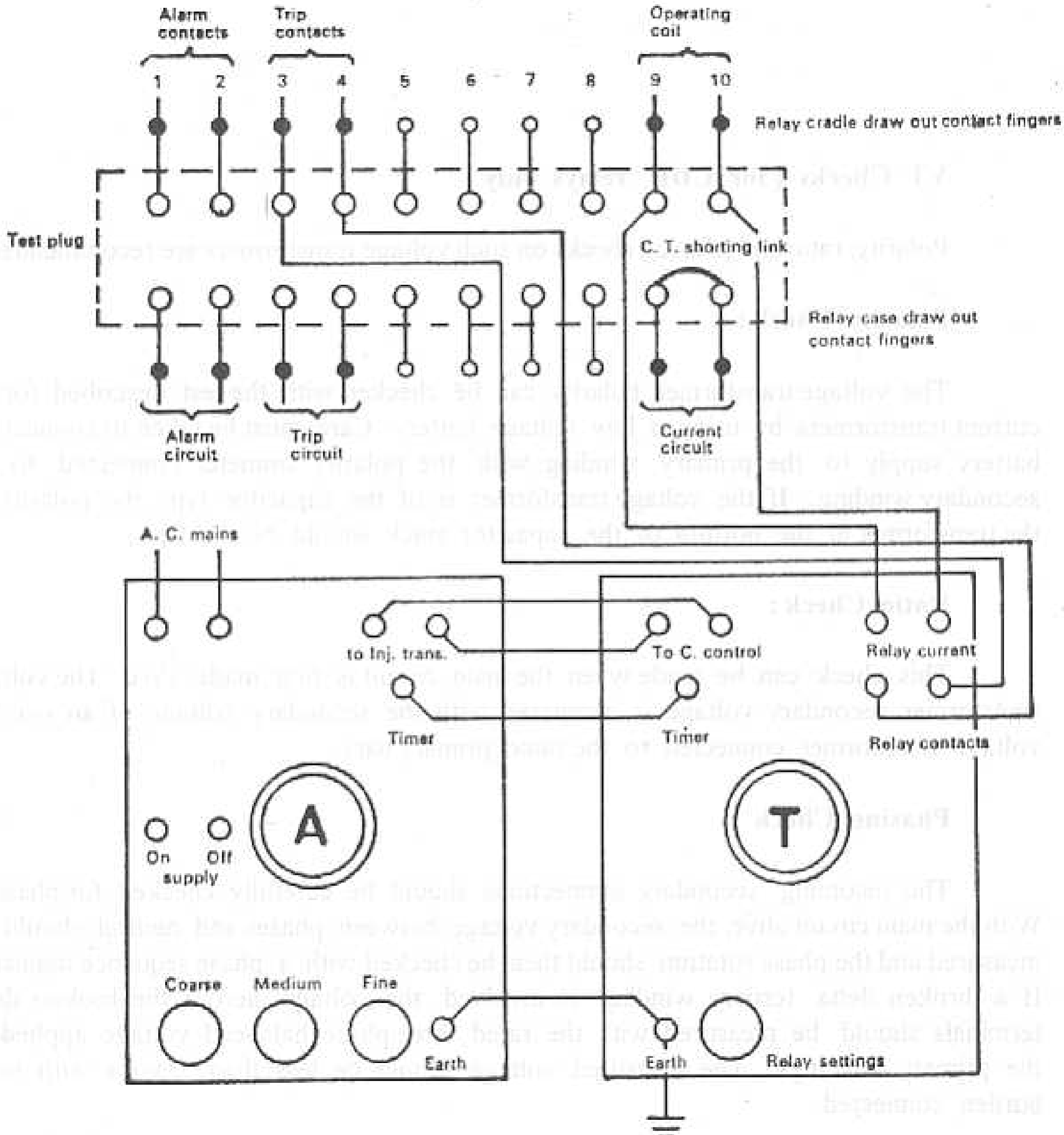


Fig 16. Connections for testing single pole CDG relays in draw out cases using GEC ALSTHOM overcurrent test equipment type CFB

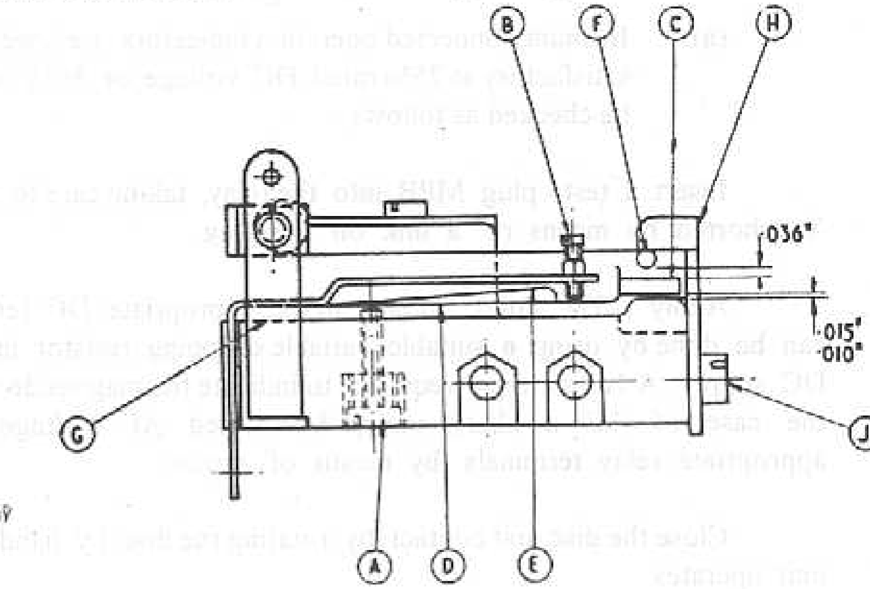


Fig. 17. Cup unit assembly

(b) If series seal - in units are fitted, their operation can also be checked in a similar manner. However, the value of the resistor used in the test circuit should be high enough to limit the test current to approximately the pick-up value of seal - in units, i.e. either 0.2 amp. or 2.0 amp. depending on which tap is selected on the seal - in unit.

If the Voltage operated indicators operate satisfactorily at nominal voltage and resets when voltage is removed, it is not essential to check their operation at lower voltages, as specified in this test. Similarly, the operation of the series seal - in units can be checked by energising the circuit in which the indicator is connected.

(c) In the case of CDG series trip relays, it is not necessary to conduct this test because the operation indicator of this relay is operated by current flowing in the secondary winding of the internal current transformer of the relay.

(d) In the case of self-powered relays, the auxiliary element operation is checked along with the operation of the disc unit and as such no other operational check is called for the auxiliary element.

4.6 Secondary Injection Tests :

4.6.1 Overcurrent Unit (CDG and CDD Relays) :

To check the accuracy of the relay current and time setting, it is necessary to carryout secondary injection tests on the relay using current of sinusoidal wave-form within practical limits. GEC ALSTHOM portable test equipment type CFB, which is described in detail in the publication TP : RL : 473, is specially designed for carrying out these tests.

The test equipment comprises a power supply unit and an injection transformer unit. The power supply unit is used for the control of test current, the setting being achieved in three stages viz., coarse, medium and fine adjustments. Current indication is given by a built - in ammeter.

The injection transformer unit is, in effect, an impedance matching unit which couples the relay under test to the power supply unit and limits the range of control required in the power supply for the widely divergent currents that can be supplied by the equipment. The injection transformer is provided with secondary tappings which are chosen to correspond with the relay current setting. This ensures that the relay impedance is small when reflected back into the primary circuit of the injection transformer, and reduces the harmonics in the test current which occur due to the saturation of the relay magnetic circuit.

The test set incorporates a digital timer with a resolution of 0.1 and 1 second.

Fig. 16 illustrates the connection for testing single pole relays in a drawout case. For testing the disc unit in CDD relays, care should be taken to ensure that the cup unit contact is maintained in ' closed ' position. They can be conveniently shorted at the terminal board inside the relay. It should be checked that the cup unit controls the operation of the disc unit.

When using the test set, the test current should be adjusted approximately to the required value, with the relay coil shorted to prevent unnecessary heating. The short should then be removed for final adjustment of the required current and shorted again. The timing device should now be reset and the relay checked to ensure that it is reset completely. The short across the relay coil should once again be removed and the coil put into circuit. The relay shorting switch starts the timing device and the operation of the relay contacts stops it, leaving the relay operating time registered on the timer dial.

NOTE 1 :

The test set described above is portable and includes precision ammeter and timing equipment. It has negligible harmonics in the test current and therefore, accurate timing tests can be carried out on induction disc relays. Where such a test kit is not available, use a voltage between 100 and 250 volts with a series current limiting resistor to make the circuit highly resistive, and therefore conducive to good wave form. Instruments used should be of known accuracy conforming generally to industrial portable instrument grade of B.S. 89.

NOTE 2 :

On series tripping relays the alarm contacts where provided can be used for timing tests. Where alarm contacts are not provided, a test screw has been provided on the auxiliary unit contact block. By disconnecting the lead to the screw, the disc relay contacts can be used for timing tests.

The following tests are recommended for each relay :

(a) With the current setting on the rated tap (see Tables 1 and 2 for identifying rated taps) and time multiplier setting 0.3, check that the disc starting current (i.e. the current at which the disc just begins to move but does not complete its travel to close the contacts) is within the limits specified in Table 3.

(b) With the current setting on the rated tap and T.M. setting 0.3, check that the disc closing current (i.e. the minimum current at which the disc completes its travel to close its contacts) is within the limits specified in Table 3.

(c) With the current setting on the rated tap and T.M setting 1.0, check the operating times of the relay at 2, 5, 10 and 20 times the plug setting current except CDG 12 relay which should be checked at 2, 5, and 10 times only. These times should be within the tolerances specified in Table 3.

(d) With the current setting on the rated tap and T.M. setting 0.5, check the operating times of the relay at 10 times the plug setting current. These times should be within the tolerance specified in Table 3.

TABLE 1

Tap currents and positions on plug board for overcurrent relays, type CDG 11 and disc units of type CDD 21 relays.

MULTI - STRAND COILS WITH STANDARD TAPS

Tap nos.	Current Range - Amperes				
	2.5 - 10	1 - 4	0.5 - 2.0	0.2 - 0.8	0.1 - 0.4
1	2.5	1.0	0.5	0.2	0.1
2	3.75	1.5	0.75	0.3	0.15
3	5.0	2.0	1.0	0.4	0.2
4	6.25	2.5	1.25	0.5	0.25
5	7.5	3.0	1.5	0.6	0.3
6	8.75	3.5	1.75	0.7	0.35
7	10.0	4.0	2.0	0.8	0.4

NOTES :

(i) The taps on the plug - board are numbered 1 to 7 from left to right viewed from the front of the relay.

(ii) **Tap No. 3 is the rated tap.**

(iii) Taps for CDG 11 series trip relays are identical to these.

(iv) Type CDG 12 relay has only two taps, either 0.15 and 0.2 amp. or 0.75 and 1.0 amp. **The higher taps are rated taps** i.e. 0.2 amp. or 1.0 amp.

TABLE 2

Tap currents and positions on plug board for overcurrent relays, types CDG 13 and CDG 14 and disc units of type CDD 23 and CDD 24.

MULTI - STRAND COILS WITH PREFERRED TAPS

Tap nos.	Current Range - Amps.				
	2.5 - 10	1 - 4	0.5 - 2.0	0.2 - 0.8	0.1 - 0.4
1	2.5	1.0	0.5	0.2	0.1
2	3.0	1.2	0.6	0.24	0.12
3	3.75	1.5	0.75	0.3	0.15
4	5.0	2.0	1.0	0.4	0.2
5	6.0	2.4	1.2	0.48	0.24
6	7.5	3.0	1.5	0.6	0.3
7	10.0	4.0	2.0	0.8	0.4

NOTES : (i) The taps on the plug - board are numbered 1 to 7 from left to right viewed from the front of the relay.

(ii) **Tap No. 4 is the rated tap.**

(iii) Taps for CDG 14 series trip relays are identical to these.

TABLE 3

PERFORMANCE CHART FOR CDG RELAYS AND DISC UNITS OF TYPES CDD 21, 23 AND 24

Relay Type	Starting current on rated tap at TMS 0.3	Closing current on rated tap at TMS 0.3	Operating time in Seconds at TMS 1.0 (Times the rated plug - setting current)				Operating time in seconds at TMS 0.5 at10 times the rated plug setting current
			2	5	10	20	
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
CDG11including series trip(3.0sec. relay) & disc unit of type CDD 21	103%-105% of current setting	Not more than 130% of current setting	10.0 ±12.5%	4.3 ±7.5%	3.0 ±7.5%	2.22 ±7.5%	1.5
CDG11 including series trip(1.3sec. relay) & disc unit of type CDD 21	- do -	- do -	3.85 ±12.5%	1.777 ±7.5%	1.3 ±7.5%	1.007 ±7.5%	0.65 ± 7.5%
CDG 12	85% - 105% of current setting	Not more than 110% of current setting	75.5 ±12.5%	30.0 ±7.5%	17.8 ±7.5%	-	8.9 ±7.5%
CDG 13 & disc unit of type CDD 23	103%-105% of current setting	Not more than 130% of current setting	17.0 ±12.5%	2.725 ±7.5%	1.53 ±7.5%	1.15 ±7.5%	0.77 ±7.5%
CDG14 including series trip and disc unit of type CDD 24	103%-105% of current setting	Not more than 130% of current setting	17.2 ±12.5%	2.02 ±7.5%	0.6 ±7.5%	0.33 ±7.5%	0.3 ±7.5%

NOTE : If the tolerances specified above work out to less than 0.1 second, a tolerance of 0.1 second is to be taken.

(e) With the relay set at the current and time multiplier settings intended in service, check the operating time 2, 5, 10 times the setting current. The anticipated operating times can be computed from the time - current characteristics; see Figs. 27 to 31.

If the actual service settings are not available, check continuity of all the tappings on the relay. Check also that the plug bridge shorting contact is satisfactory. Record all the results.

NOTE :

The time multiplier and current setting are calibrated before despatch and **does not require adjustment**. However, if the time - current characteristics have been lost, due to brake magnet having been disturbed, or the control spring suppression altered, or after fitting of new parts, the relay can be recalibrated as follows :

Set the time multiplier on 1.0 and the current setting on the rated tap of the plug board (except CDG 12, where higher tap setting should be used), and adjust the spring suppression by turning the small disc between the time multiplier and the spring until the starting and closing currents of the relay are within the limits specified in Table 3.

If the operating time at 10 times the plug setting current is not correct, the permanent magnet position may require adjustment, but this would only be in the case of damage to the relay or replacement of magnets.

Check the operating times at twice and ten times the plug setting current using the current and time setting intended in service. Adjustment of this time at twice plug setting can be obtained by a slight change in the spring suppression.

If the spring suppression has to be altered at two times plug setting current, the starting and closing currents and the operating time at 10 times plug setting current should be rechecked as stated earlier.

It should be noted that the time multiplier scale is calibrated at 10 times plug setting current.

4.6.2 DIRECTIONAL UNIT (CDD Relays)

4.6.2.1 Contact Clearances :

The contact assembly and contact clearances are shown in Fig. 17. To set the contacts to these tolerances the following procedure should be adopted :

(a) Slacken off screws A and B.

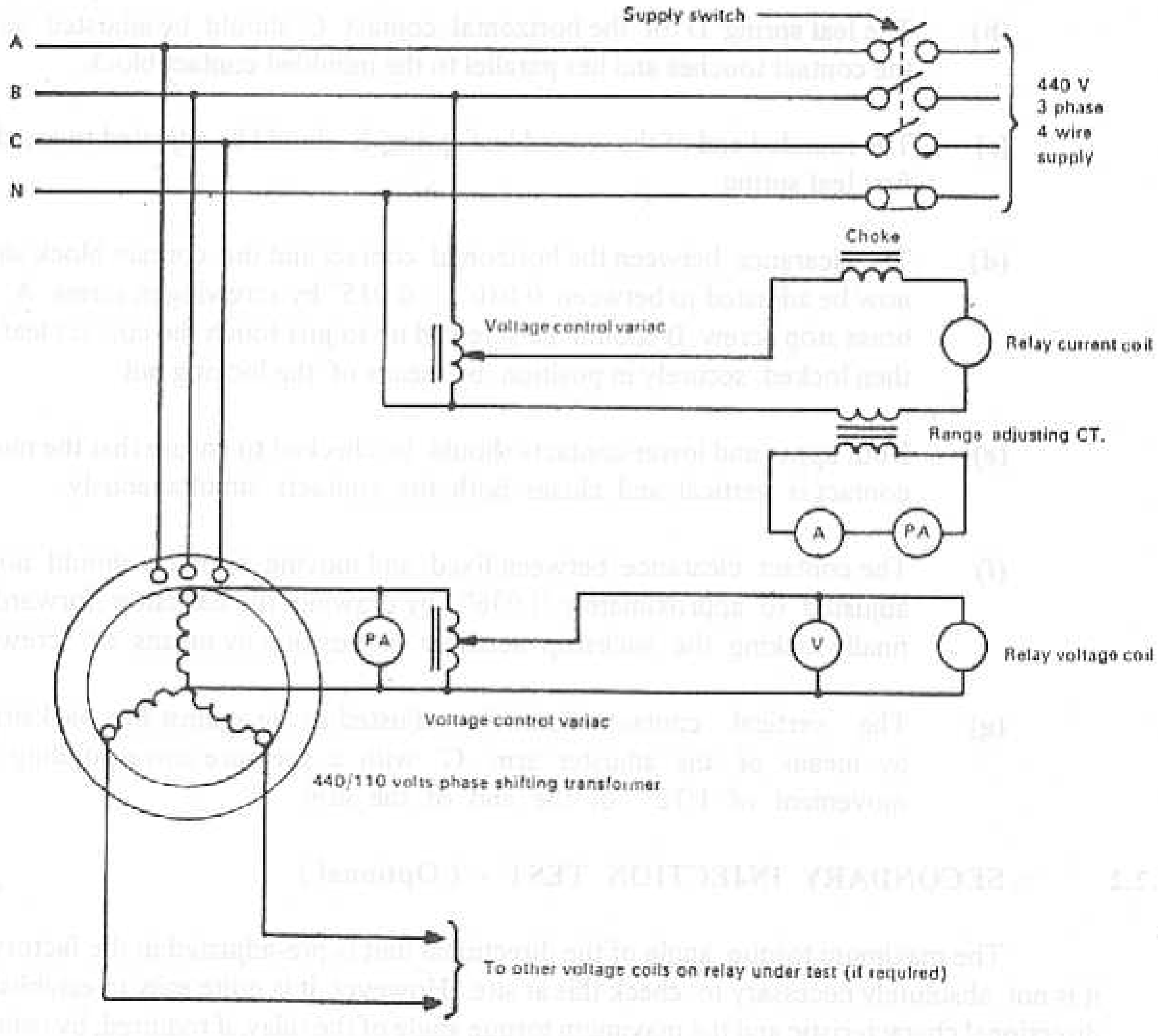


Fig. 18. Test equipment for checking maximum torque angle of CDD relays

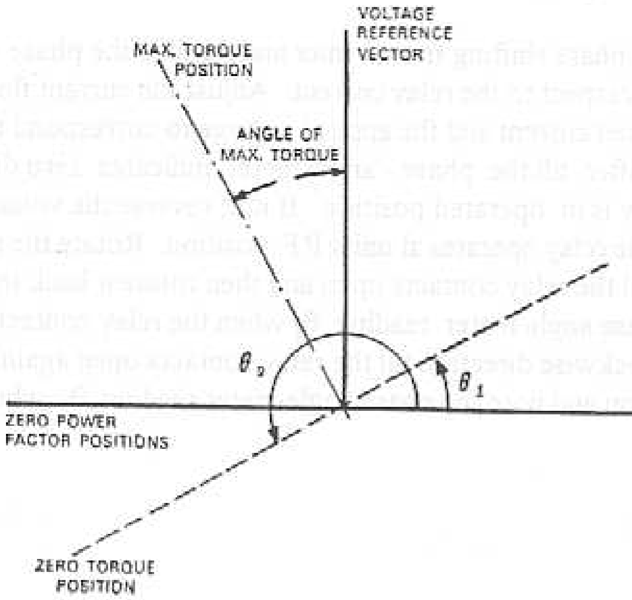


Fig. 19. Diagram to check angle of maximum torque

(b) The leaf spring D of the horizontal contact C should be adjusted so that the contact touches and lies parallel to the moulded contact block.

(c) The rounded end of the second leaf spring E should be adjusted to touch the first leaf spring.

(d) The clearance between the horizontal contact and the contact block should now be adjusted to between 0.010" - 0.015" by screwing in screw A. The brass stop screw B should be screwed up to just touch the contact leaf and then locked securely in position by means of the locking nut.

(e) Both upper and lower contacts should be checked to ensure that the moving contact is vertical and closes both the contacts simultaneously.

(f) The contact clearance between fixed and moving contacts should now be adjusted to approximately 0.036" by drawing the backstop forward and finally locking the backstop securely in position by means of screw **J**.

(g) The vertical contact should be adjusted to lie against the backstop **H** by means of the adjuster arm **G** with a pressure corresponding to a movement of 1/32" of the end of the arm.

4.6.2.2 SECONDARY INJECTION TEST - (Optional)

The maximum torque angle of the directional unit is pre-adjusted in the factory and it is not absolutely necessary to check this at site. However, it is quite easy to establish the directional characteristic and the maximum torque angle of the relay, if required, by using the equipment and connections shown in Fig. 18.

The method illustrated uses a phase shifting transformer and permits the phase angle of the relay voltage to be varied with respect to the relay current. Adjust the current flowing through the relay to correspond to rated current and the applied voltage to correspond to the rated voltage. Rotate the phase - shifter till the phase - angle meter indicates zero degree (i.e. unity P.F.). Check that the relay is in operated position. If not, reverse the voltage or current connections and check that the relay operates at unity P.F. position. Rotate the phase shifter in the clockwise direction until the relay contacts open and then rotate it back in anti-clockwise direction and note the phase angle meter reading θ_1 when the relay contacts just close. Continue to rotate in anti - clockwise direction till the relay contacts open again, then rotate backward in clockwise direction and note the phase angle meter reading θ_2 when the contacts just close.

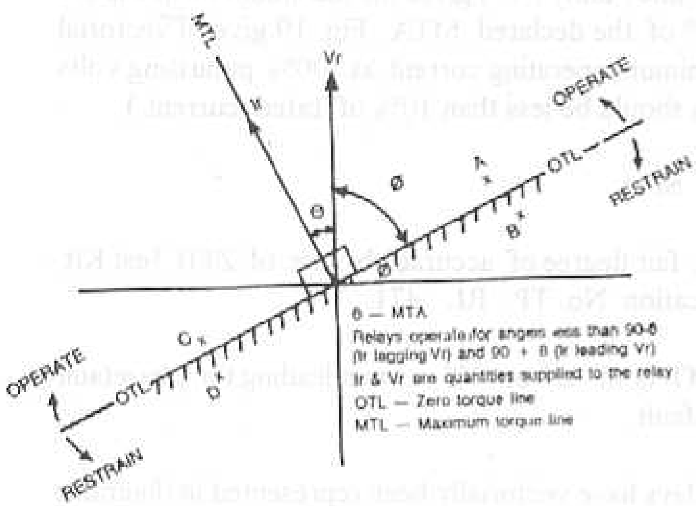


Fig. 20(a) Phase fault relays.

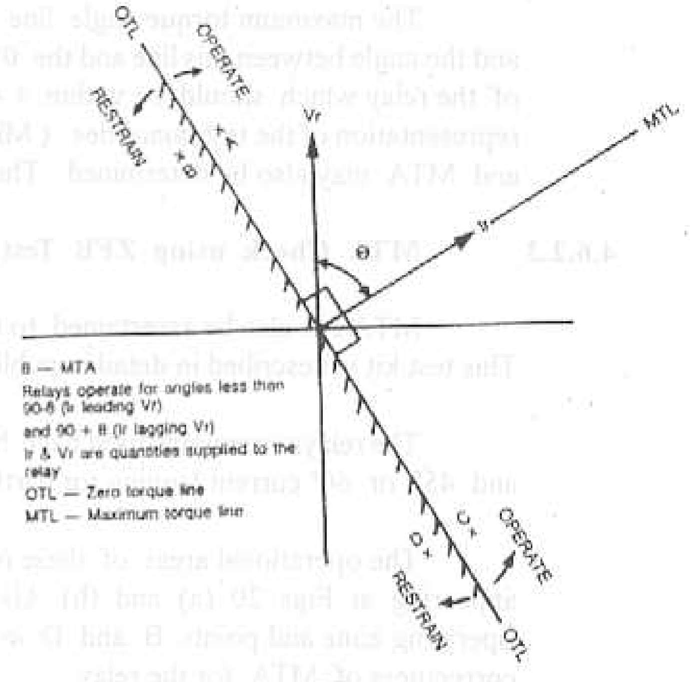


Fig. 20(b) Earth fault relays

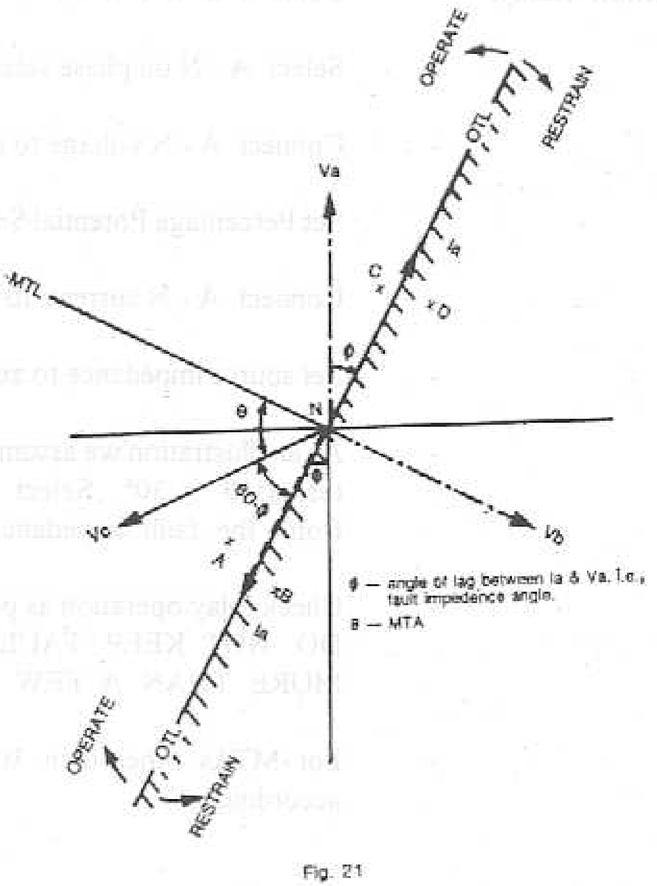


Fig. 21

The maximum torque angle line of the relay is given by the bisector of $\theta_1 - \theta_2$ and the angle between this line and the 0° line (unity P.F.) gives the maximum torque angle of the relay which should be within ± 4° of the declared MTA. Fig. 19 gives a vectorial representation of the test quantities. (Minimum operating current at 100% polarising volts and MTA may also be determined. This should be less than 10% of rated current).

4.6.2.3 MTA Check using ZFB Test Set :

MTA can also be ascertained to a fair degree of accuracy by use of ZFB Test Kit. This test kit is described in detail in publication No. TP : RL : 471.

The relays commonly used have MTAs of 45° or 30° current leading for phasefault and 45° or 60° current lagging for earthfault.

The operational areas of these relays have vectorially been represented in diagrams appearing at Figs. 20 (a) and (b). Use ZFB test kit to check points A and C in the operating zone and points B and D in the restrained zone. This would indicate the correctness of MTA for the relay.

Phasefault Relays

- Connect ZFB test kit.
- Select A - N on phase selector switch.
- Connect A - N voltage to relays.
- Set Percentage Potential Selector to 100%.
- Connect A - N current to relays.
- Set source impedance to zero.
- As an illustration we assume MTA of the relay under test as $\theta = 30°$. Select angles given in Table 4A from the fault impedance box.
- Check relay operation as per Table 4A.
  DO NOT KEEP FAULT PB PRESSED FOR MORE THAN A FEW SECONDS.
- For MTAs other than 30° select angles accordingly.

Earthfault Relays : - Ref. Fig. 21. It will be seen that combination of voltage and current vectors **Vc** and **Ia** respectively give angle of lag of $120 + \phi$. Similarly the combination of voltage and current vectors of Vc and -Ia give angles of lead of $60 - \phi$.

- Connect ZFB test kit.
- Select A - N on phase selector switch.
- Connect C - N voltage to relays.
- Connect A - N current to relays.
- Set source impedance to zero.
- As an illustration we assume MTA of the relay under test as $\theta = 60°$. Select angles given in Table 4B from the fault impedance box.
- Check relay operation as per Table 4B. DO NOT KEEP FAULT PB PRESSED FOR MORE THAN A FEW SECONDS.
- For MTAs other than 60° select angles accordingly.

4.7 TRIP AND ALARM CIRCUIT CHECK :

During the secondary injection tests, the trip, inter - trip and alarm circuits are usually rendered inoperative by removel of isolating links, relay trip - latches etc. It is thus essential that on completion of these tests, the tripping, inter - tripping and alarm circuits should be checked.

Close the relay contacts by hand after restoring all the links and latches to their original positions and check that the correct circuit - breaker is tripped and the right alarm comes on. Ensure that the flagging is correct and that there is no maloperation of any other apparatus.

4.8 LOAD TESTS :

After all the tests are complete, energise the protected apparatus and check that the correct secondary currents are flowing through the relays. This can be done by using an ammeter connected to a split - plug. In the case of single pole relays, split plug should be inserted in terminal No. 9 or 10 of the relays and the ammeter reading taken. Where relays with special wiring diagrams on triple pole relays are involved, wiring diagram should be consulted for the correct terminal numbers.

TABLE 4A

S.No.	Angles selected on Fault Impedance Box (Ref. Note 4)	RELAY OPERATION WITH	
		CURRENT SWITCH POSITION IN NORMAL	CURRENT SWITCH POSITION IN REVERSE
1	$Ø = (90 - θ) - 5° = 55°$	OPERATE, (A)	RESTRAIN, (D)
2	$Ø = (90 - θ) + 5° = 65°$	RESTRAIN, (B)	OPERATE, (C)

NOTE :

1. 5° Margin has been taken to account for tolerance on MTA and equipment error.
2. Angles for current switch position in reverse will be 125° i.e. 180° – 55° for Sl.No. 1 and 115° i.e. 180° – 65° for Sl.No. 2.
3. Letters shown in parenthesis indicate the points in zones of operation/restrain referred in Fig. 20 (a).
4. Selection of voltage and current vectors on ZFB gives us current lagging voltage.

TABLE 4B

S.No.	Angles selected on Fault Impedance Box (Ref. Note. 4)	RELAY OPERATION WITH	
		CURRENT SWITCH POSITION IN REVERSE	CURRENT SWITCH POSITION IN NORMAL
1	$Ø = (θ - 30) + 5° = 35°$	OPERATE, (A)	RESTRAIN, (D)
2	$Ø = (θ - 30) - 5° = 25°$	RESTRAIN, (B)	OPERATE, (C)

NOTE :

1. 5° Margin has been taken to account for tolerance on MTA and equipment error.
2. Angles for current switch position in reverse will be 155° i.e. 180° - 25° for Sl.No. 2 and 145° i.e. 80° – 35° for Sl.No. 1.
3. Letters shown in parenthesis indicate the points in zones of operation and restrain referred in Fig. 20 (b).
4. Selection of VCN and - IAN on ZFB gives angles as current leading voltage REF. Fig. 21.

This test should be carried out on all the three phases of the system so that if the primary currents are balanced in all the three phases the secondary currents will also be balanced and this can be verified by comparing the ammeter readings for each phase. When earthfault protection is used, the earthfault relays should have negligible current under healthy balanced load conditions and this can be verified by inserting the split - plug in the earthfault relay. If the current is zero or negligible the correctness of the residual circuit will be proved.

Additional load tests for CDD Relays :

(a) The polarity of circuits connected to phasefault CDD relays employing the quadrature connection can be checked as follows :

Note the voltage 'V' across the relay voltage terminals.

Read the current 'I' through the relay current terminals.

Connect a wattmeter with its voltage coil in parallel with the relay voltage coil and its current coil in series with the relay current coil and note the wattmeter reading 'W'.

Calculate the power factor using the following equation :

$$P.F. = \sqrt{1 - \frac{W^2}{(V \times I)^2}}$$

This power factor should be checked with the reading of the particular line P.F. meter of the circuit.

If a power factor meter is not available note the voltage 'V' across secondary of voltage transformers of phases B - C and read current 'I' from current transformer of phase 'A'. Note the wattmeter reading 'W' with its voltage coil connected across secondaries of voltage transformers of phase B - C and its current coil connected in series to phase 'A' of current transformer secondary.

Calculate the power factor using the equation :

$$P.F. = \sqrt{1 - \frac{W^2}{(V \times I)^2}}$$

If this power factor is the same as the one calculated at relay terminals, the wiring is correct.

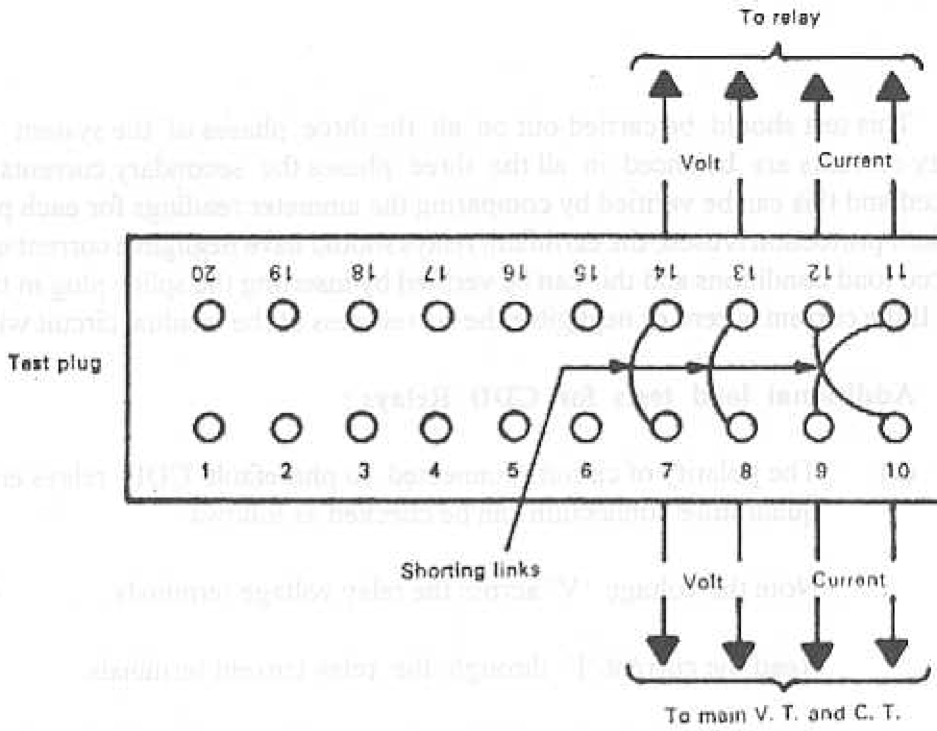
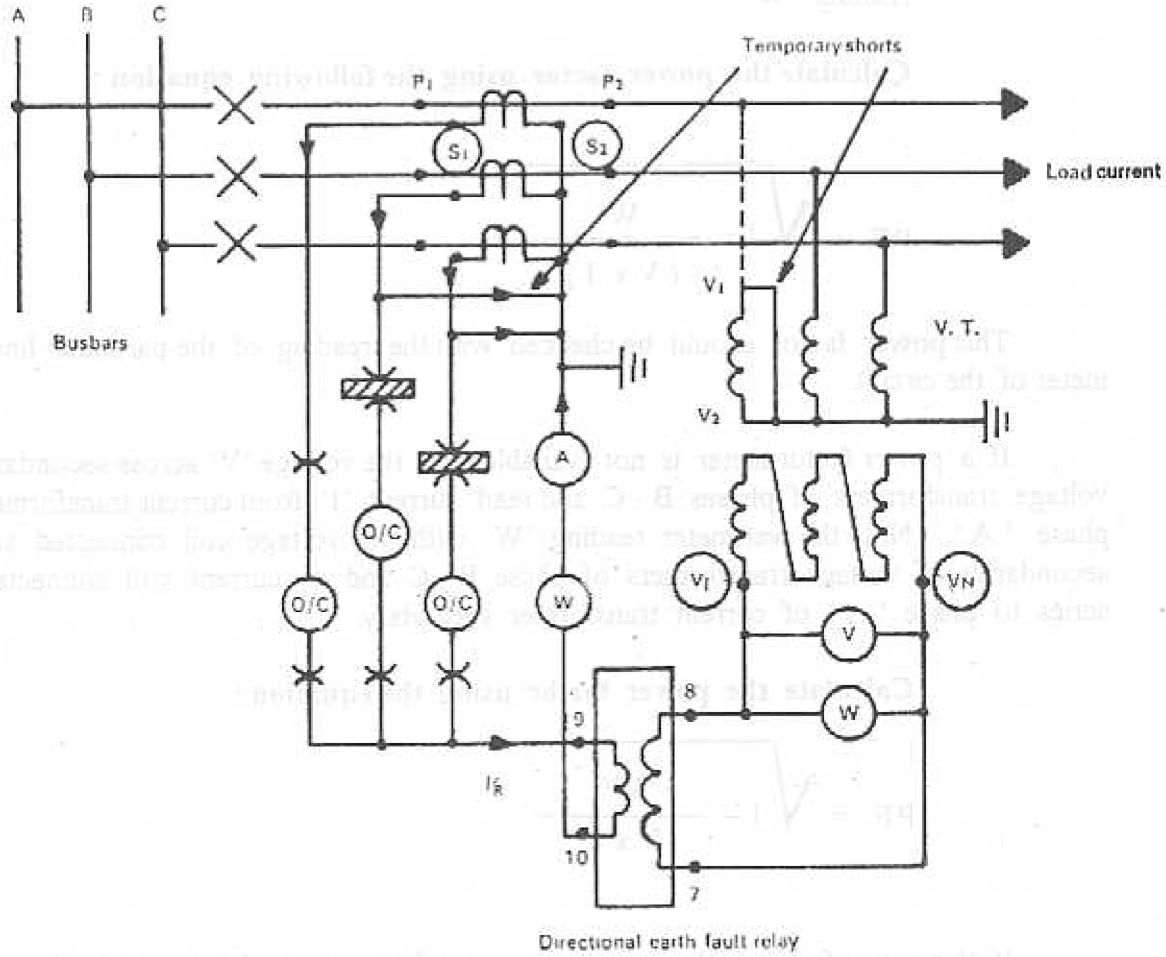


Fig. 22. Cross connection on test plug to reverse current seen by relay



23. Load test on directional earthfault relay

If the load current is appreciable and its direction is not in doubt, the polarity tests on directional phasefault relays can easily be made. The relay cup unit contacts should close when the load current is in operating direction and open when the load current is in the reverse direction. The load conditions can be reversed to the relay by cross - connecting the current leads of the tests plug as shown in Fig. 22. This avoids interference with the cubicle wiring and ensures that the connections are restored correctly. Utmost care has to be taken, however, when inserting or withdrawing the test - plug so that current transformers are not open - circuited even momentarily.

(b) Directional earthfault relays are usually energised from the broken delta winding of a three phase voltage transformer or three single phase transformers and the residual circuit of the main current transformers. Therefore, under normal load conditions, these relays get neither current nor voltage and it is necessary to simulate earthfault conditions to establish the polarity of their connections. Fig. 23 illustrates one method of simulating phase to earthfault conditions.

The primary winding of the A - phase voltage transformer is disconnected and shorted whilst the current transformer secondaries of the other two phases (viz. B and C phase) are shorted and disconnected. Under this condition with the load current flowing in the operating direction, the cup unit contacts should close and, with the load current in the reverse direction, the relay should restrain. Cross - connections can be applied by means of the test - plug as described in (b) earlier but adequate care should be taken to avoid open - circuiting of current transformers. **The original connections should be RESTORED AFTER THE TEST.**

(c) Fig. 24 shows how open delta voltage can be obtained without any alteration in the primary circuit of the P.T. It may also be noted that Y - Phase P.T. Secondary has been isolated and Y - Phase current let through. This avoids any ambiguity arising out of correct phase identifications of CTs and PTs. It is important to know the power flow directions both active and reactive in order to ascertain the relay response. Use of a standard Phase - Angle meter is recommended to avoid total reliance on panel meters.

(d) Load tests on current polarised directional earthfault relays can be carried out as follows. A - phase current should be fed to the relay by shorting and disconnecting B and C phase current transformer secondaries. The relay operating and polarising coils should be connected in series for this test by shorting terminals 9 and 6 and connecting the CT leads to terminals 10 and 5. With load current following in the operating direction, the cup unit contact should close under this condition and vice versa.

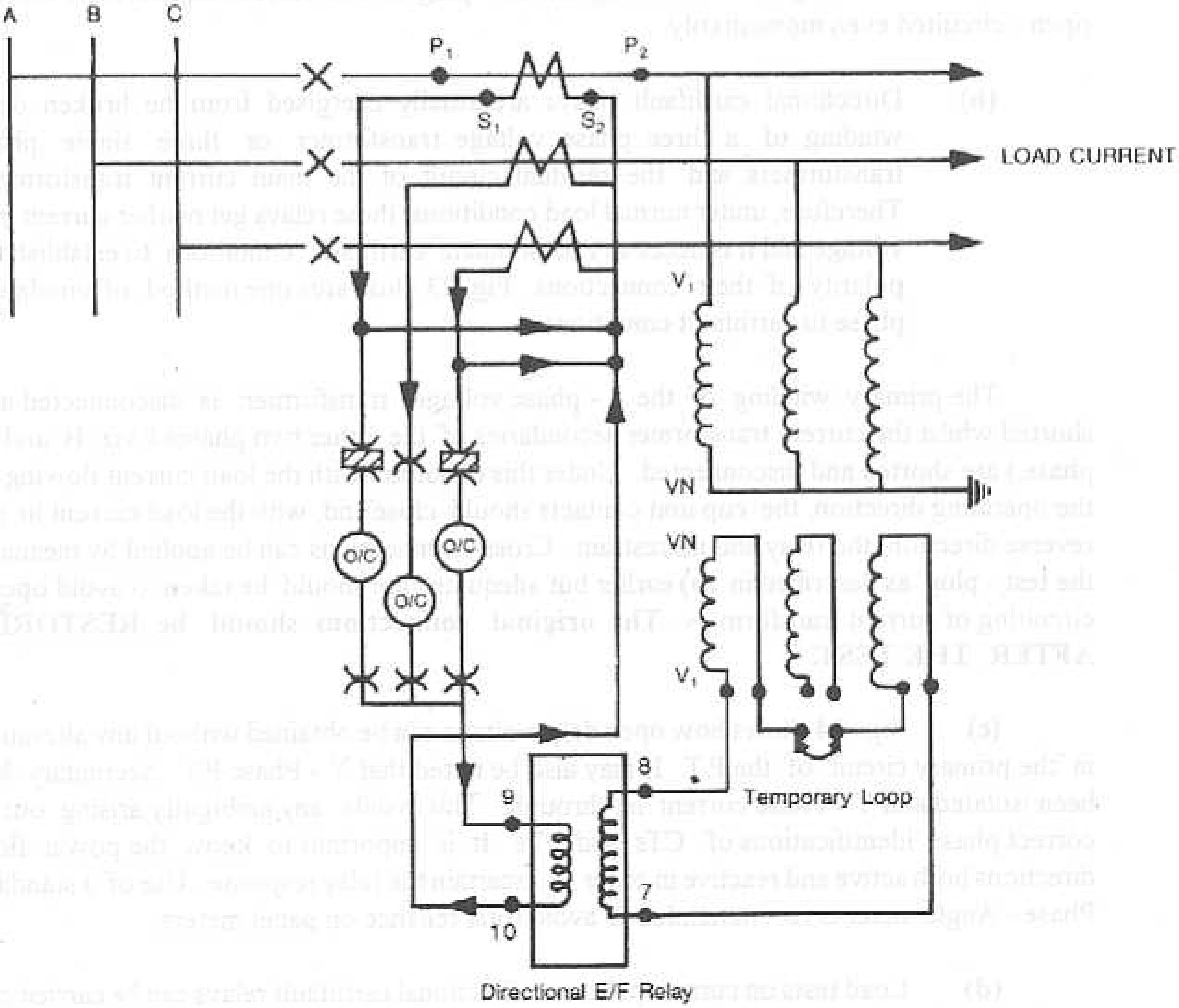


Fig. 24. Load Test on Directional Earth Fault Relay — Alternative method

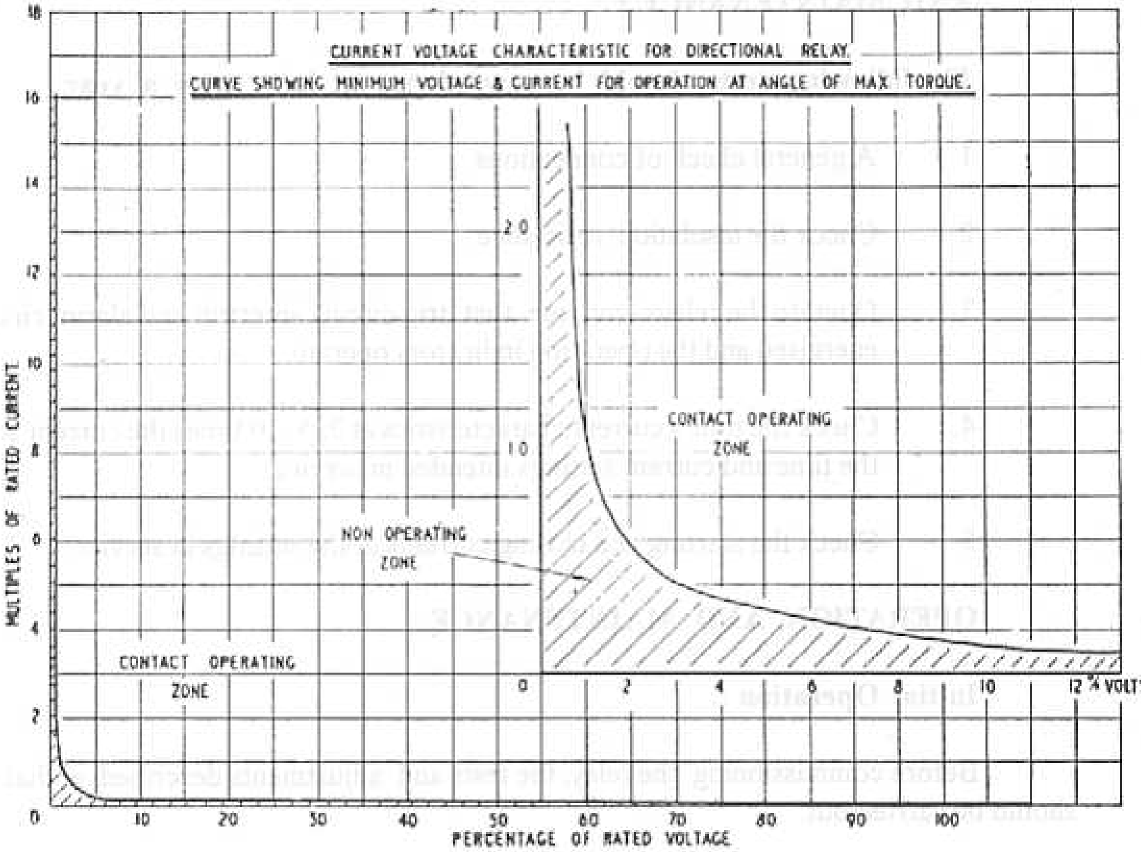


Fig. 25. Current voltage characteristic for directional relay

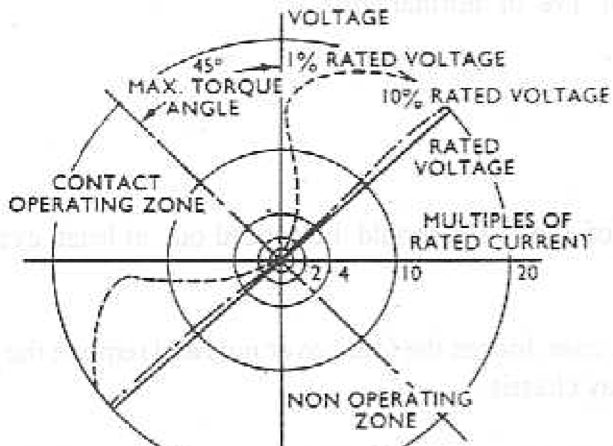


Fig. 26. Characteristic of directional relay having maximum torque angle of 45° lead

5. **RECOMMENDED CHECK TESTS DURING ANNUAL SERVICING AND MAINTENANCE :**

The following tests should be carried out at least once a year.

1. A general check of connections.

2. Check the insulation resistance.

3. Operate the relays and see that trip circuit, intertrip and alarm circuits are energised and the operation indicators operate.

4. Check the time - current characteristics at 2, 5, 10 times the current setting at the time and current settings intended in service.

5. Check the starting and closing currents at the settings in service.

6. **OPERATION AND MAINTENANCE**

Initial Operation :

Before commissioning the relay, the tests and adjustments described in that section should be carried out.

Operating Limits : (Directional Unit)

The current / voltage characteristics showing values of current and voltage for operation are shown in Fig. 25. The polar diagram (Fig. 26) shows the phase angle, operating value at 100%, 10% and 1% of normal volts.

MAINTENANCE

Inspection and Tests :

Inspection and check testing of the relays should be carried out at least every six months.

To inspect a relay in a drawout case, loosen the four cover nuts and remove the cover, rotate the latches and slide out the relay chassis.

To inspect a relay in a non - drawout case loosen the four cover nuts and take off the cover, unscrew the four wrapper screws and remove the case wrapper.

The tests are listed in the section on Commissioning. The relay should be inspected for the following points.

Contacts :

All contacts and drawout contact fingers should be inspected to ensure clean contact surfaces. When contacts require cleaning, a burnishing tool should be used. On any account they should not be cleaned with knives, files or emery paper, as these may leave scratches or particles or emery dust which cause arcing and may prevent contacts from closing. Contact clearances of the directional unit should be checked and adjusted if necessary as described in the section on Commissioning.

Bearing (Overcurrent Unit) :

The lower bearing consists of a spring - loaded synthetic sapphire cup jewel, and a phosphor - bronze ring mounted above it to prevent any lateral movement of the highly polished steel rotor pivot. It can be removed for inspection by turning the spring mounted holding clip at the bottom of the relay frame to the left or right, the bearing and mounting can then be removed.

The upper bearing consists of a steel guide pin extending through an axial hole in a brass cap at the top of the rotor shaft. The guide pin and mounting can be removed by undoing the locking nut at the top of the frame. It should not be removed while the bottom bearing is out, as great care must be taken to prevent damage to the control spiral.

If it should be necessary to remove the disc to inspect the rotor bearings, the control spiral must be unsoldered. The rotor can then be removed without disturbing any other part of the relay.

Bearings (Directional Unit)

The pivots and bearings should be examined and replaced only if the electrical performance is not within the current / voltage characteristics shown in Fig. 25.

To carry out this inspection the contact block should be first removed by loosening the block securing screws on the bridge and sliding out the block. The bridge should now be removed by unscrewing the securing screws tapped into the supporting pillars.

Top and bottom bearings can then be screwed out of their holders and the cup lifted out for inspection of the pivots.

N.B. The contact operating arm is locked securely to the cup assembly, and should not be moved, otherwise the setting of the adjuster vane will be disturbed.

Induction Disc :

The disc should be examined for particles of dust or other foreign matter on its surface, and, if necessary, these should be removed with a feather.

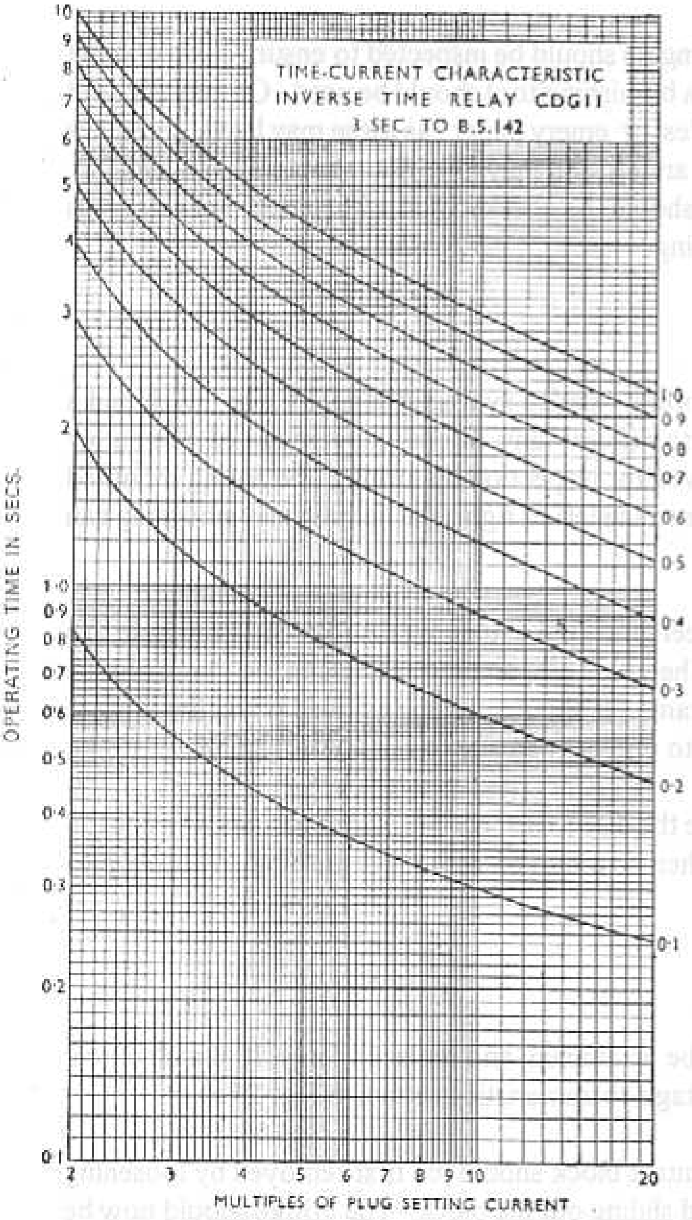


Fig. 27. Time current characteristic of CDG 11 relay 3.0 sec. relay

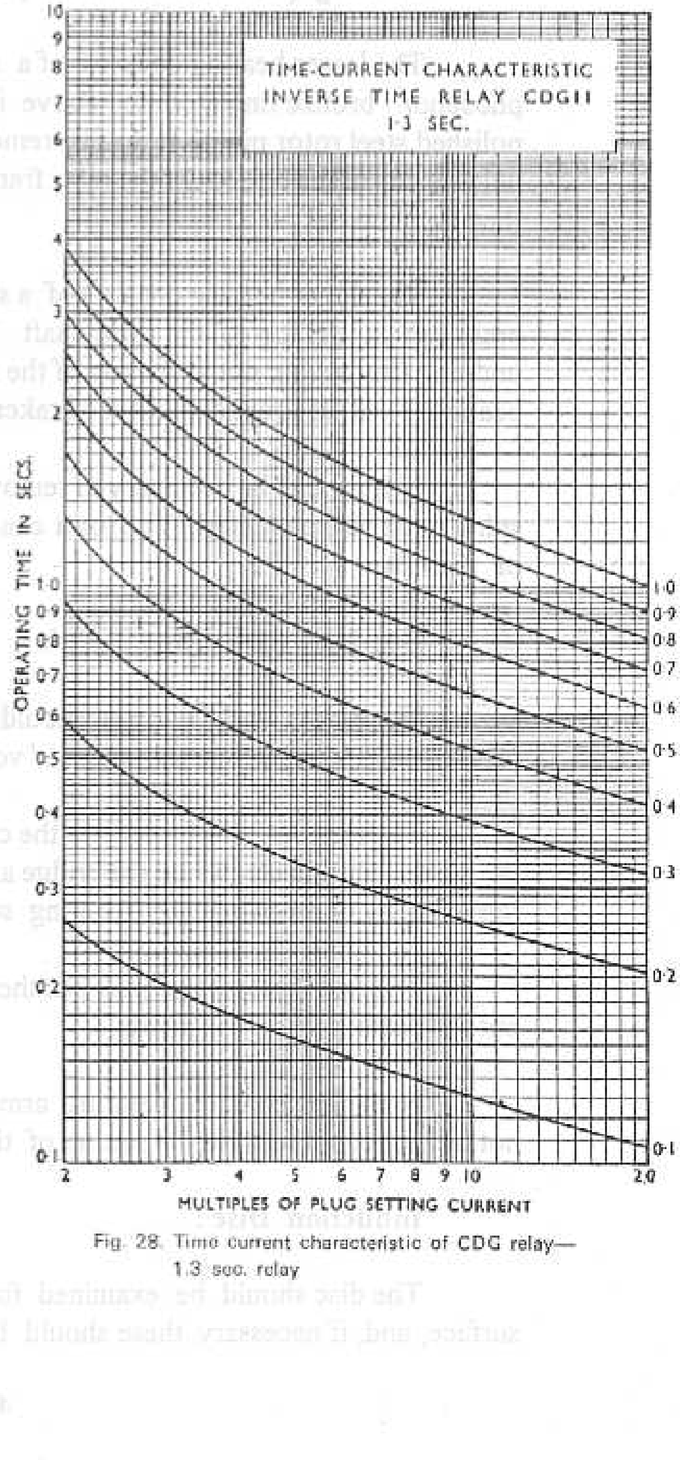


Fig. 28. Time current characteristic of CDG relay—1.3 sec. relay

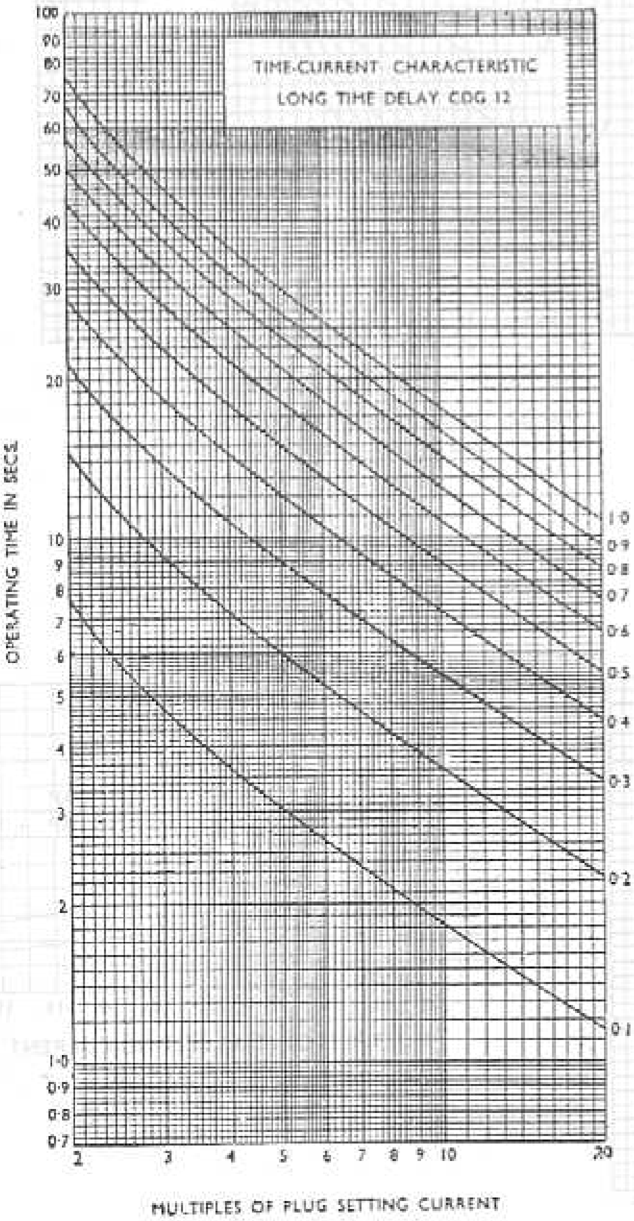


Fig. 29. Time current characteristic of CDG 12 relay

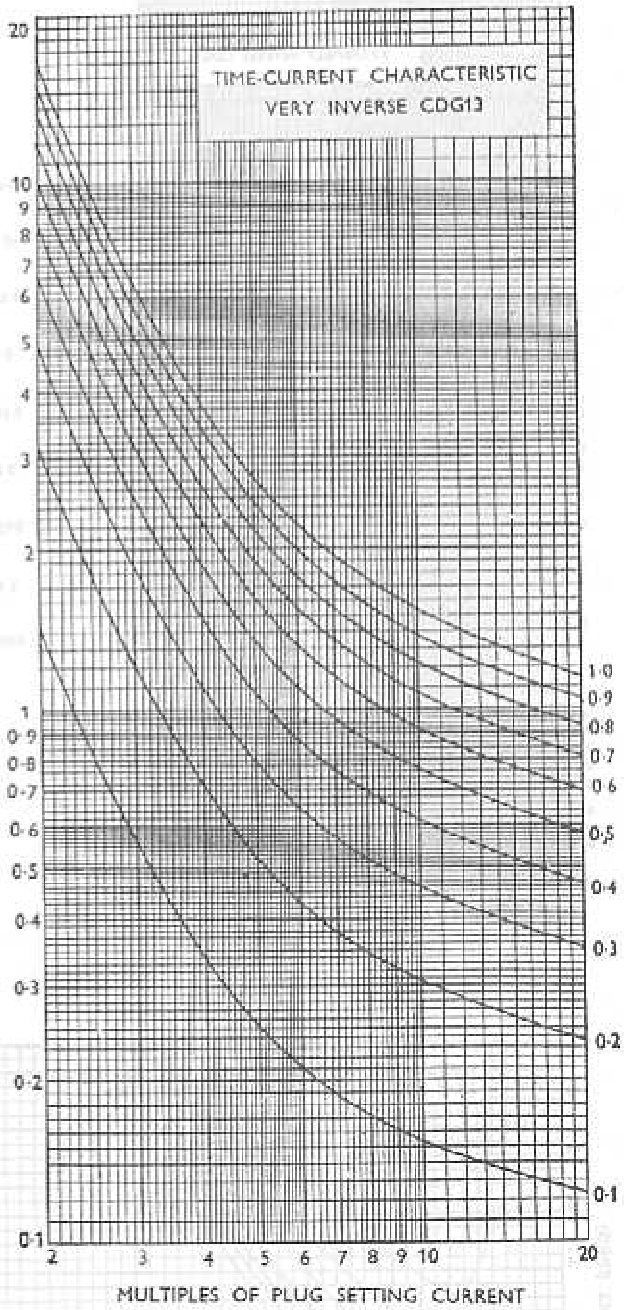


Fig. 30. Time current characteristic of CDG 13 relay

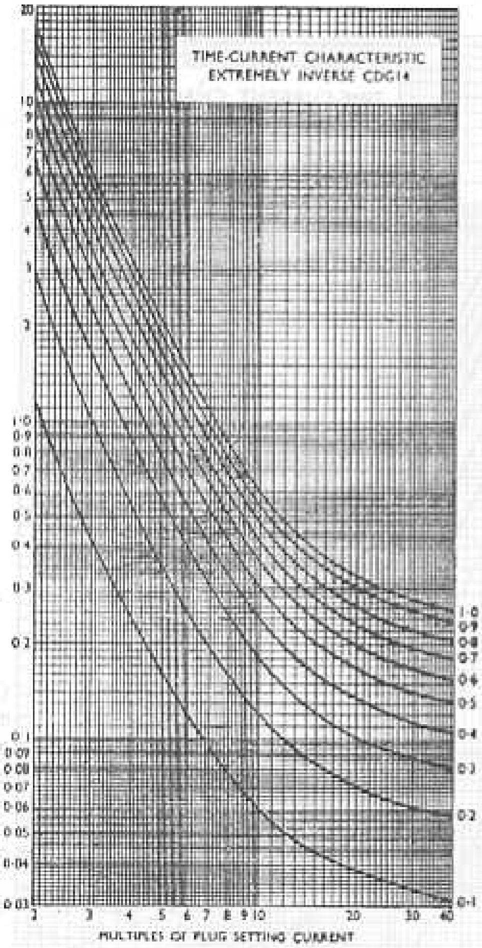


Fig. 31. Time current characteristic of CDG 14 relay

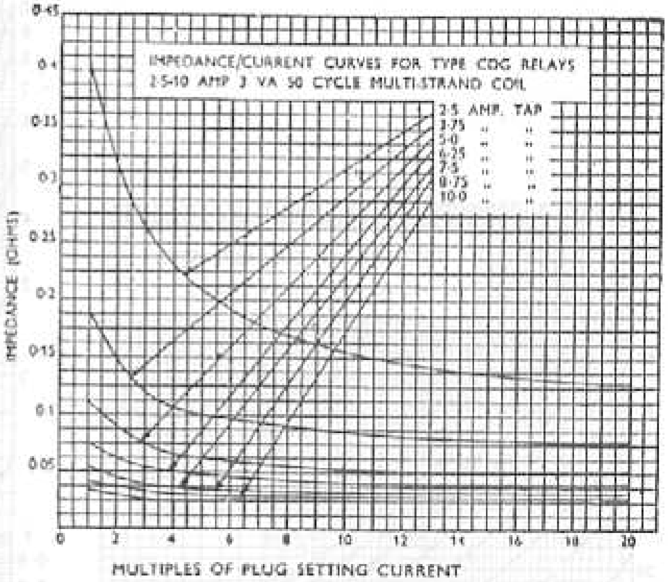


Fig. 32. Typical impedance/current curves of CDG 11, 3VA relay

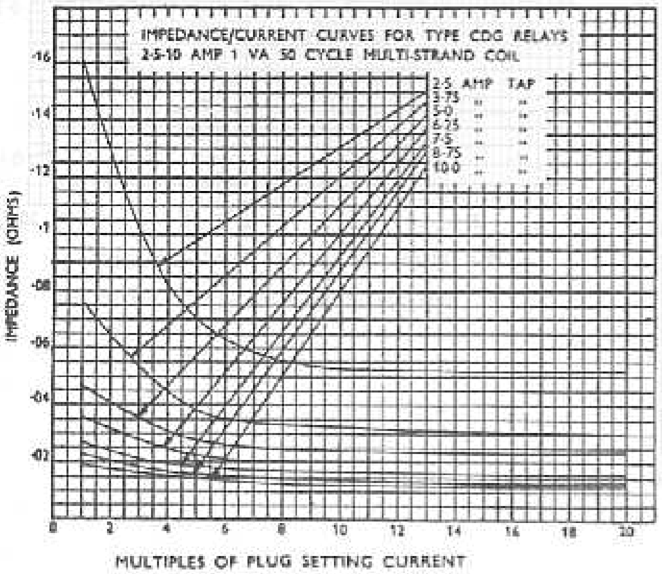


Fig. 33. Typical impedance/current curves of CDG 11, 1VA relay

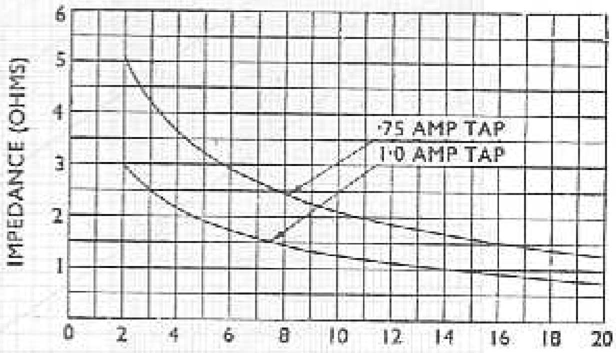


Fig. 34. Typical impedance/current curves of CDG 12

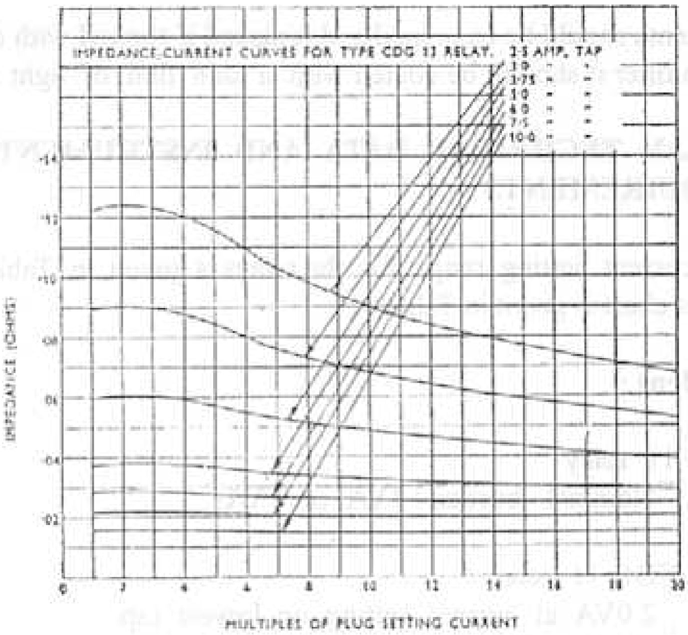


Fig. 35. Typical impedance/current curves of CDG 13 relay

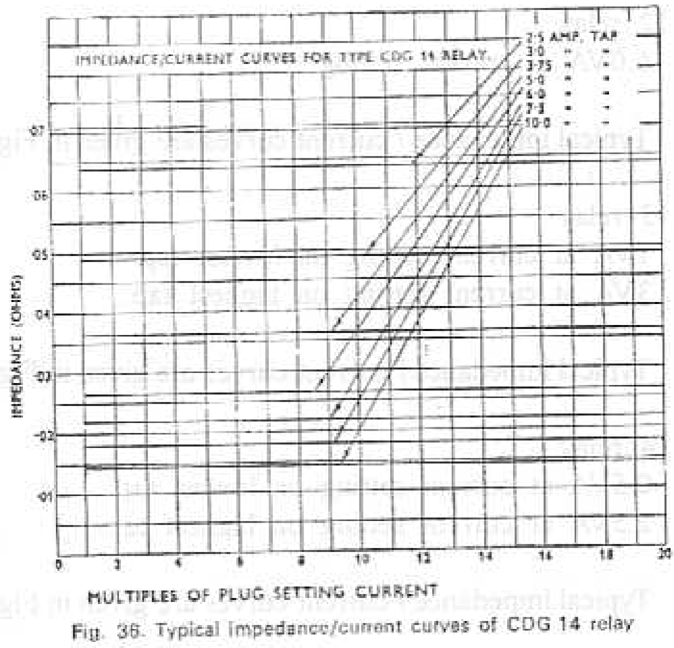


Fig. 36. Typical impedance/current curves of CDG 14 relay

Dust Filter (If Fitted) :

Contents should be examined and replaced if choked with dust. When replacing the special nylon filter it should be coated with a thin film of light machine oil.

7. RELAY TECHNICAL DATA AND INSTRUMENT TRANSFORMER REQUIREMENTS

The current setting range for the relays is given in Tables 1 & 2 and the relay performances chart is given in Table 3.

7.1 Burdens :

7.1.1 CDG 11 relay

Nominal burden : 3VA or 1VA.

7.1.2 3VA CDG 11 relay

2.0VA at current setting on lowest tap.
3.5VA at current setting on highest tap.

7.1.3 1VA CDG 11 relay

0.75VA at current setting on lowest tap.
1.3 VA at current setting on highest tap.

Typical impedance / current curves are given in Figs. 32 and 33.

7.1.4 CDG 12 relay

6.0VA at current setting.

Typical impedance / current curves are given in Fig. 34.

7.1.5 CDG 13 relay

1VA at current setting on lowest tap.
3VA at current setting on highest tap.

Typical impedance / current curves are given in Fig.35.

7.1.6 CDG 14 relay

0.5VA at current setting on lowest tap.
2.5VA at current setting on highest tap.

Typical impedance / current curves are given in Fig. 36.

7.1.7 CDG 16 relay

Burden details are as per CDG 11, 3VA relays.

7.1.8 CDD RELAYS

7.1.8.1 **Overcurrent Units :**

The burden of overcurrent units is equal to that of CDG relays.

7.1.8.2 **Directional Units :**

Current operating coils
1.0VA at rated current.

Current polarising coils
1.0VA at rated current

Voltage polarising coils
9.0VA at 110V AC
3.0VA at 63.5V AC

7.2 **Thermal Rating :**

All relays will withstand twice the setting current continuously and twenty times the maximum setting current for 3 seconds, except CDG 12 which will withstand twice the setting current continuously and 50 times the setting current for the operating time of the relay.

7.3 **Instrument Transformer Requirements :**

7.3.1 **Current transformer requirements :**

To ensure that the relay operating times are not unduly affected by C.T. saturation, they should be capable of developing a knee point voltage sufficient to circulate 20 times the plug setting current through the relay for phase and earthfaults. VA 1510 P 10 rated current transformers will be generally satisfactory for CDG and CDD relays. Where close discrimination is of less importance, a class 15p current transformer will be satisfactory.

7.3.2 **Voltage Transformer Requirements :**

For directional overcurrent protection voltage transformers conforming to accuracy class 3.0 are required. The residual voltage transformers for voltage polarised directional earthfault relays should conform to an accuracy class 10.

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